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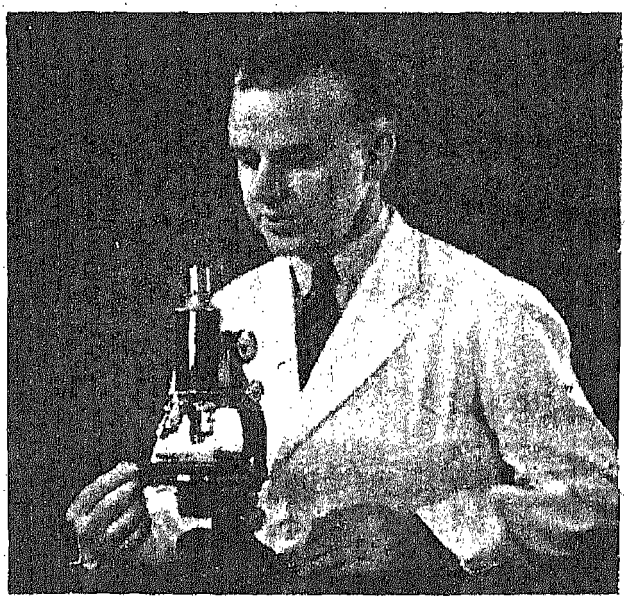
PELICAN BOOKS

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THE PERSONALITY OF ANIMALS

Nearly everybody expresses opinions about the minds of animals. These opinions are almost always based on the assumption that the animal's mentality is a simpler edition of our own. The scientist, however, will allow himself to assume nothing; he investigates the animal's mind just as he does the animal's breathing or digestion—by experiments in which as far as possible all loopholes for rash interpretation are closed. In the present book Professor Fox gives, in clear and non-technical language, the biologist's point of view on the senses, the mind and the personality of animals, together with the most important recent results of scientific investigations.

The book grew out of a two-years' weekly broadcasting programme to schools. Numerous letters showed Professor Fox that his talks were liked not only by schoolchildren but by grown-ups, who asked for more. Some of the broadcasts were on the animal mind, and this subject has been developed in the present book for listeners who had become the broadcaster's friends and for others who he hopes will be interested.



THE AUTHOR

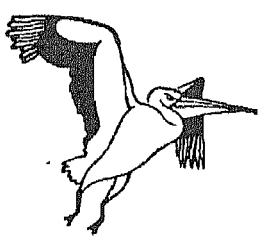
PROFESSOR H. MUNRO FOX was born in London. He went to school at Brighton College, where he was fortunate in being a day-boy; instead of regularly playing games he spent much of his spare time in searching for fossils and fishes. This decided his career, and having graduated at Cambridge he began zoological research work. After four years in the army during the the last war, he went to Egypt where he investigated the effects of the moon on life. A short popular account of this is given in his book, *Selene, or Sex and the Moon*. He returned to Cambridge as a Fellow of Caius College, and then went back to Egypt to study the passage of marine animals through the Suez Canal. When he became Professor in Birmingham University he continued his investigations on green blood in marine worms, and also built up a research school of experimental zoology. He now professes zoology at Bedford College, London. He is editor of the international scientific periodical, *Biological Reviews*, and is a Fellow of the Royal Society. Apart from research his chief enjoyments are dancing and riding horses.

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THE PERSONALITY OF ANIMALS

BY

H. MUNRO FOX, F.R.S.



Published by
PENGUIN BOOKS

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First published 1940
Reprinted 1943

MADE AND PRINTED IN GREAT BRITAIN FOR PENGUIN BOOKS LIMITED BY HARRISON AND SONS, LTD., PRINTERS TO H.M. THE KING, LONDON AND HIGH WYCOMBE

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CHAPTER I

THE ANIMAL'S WORLD

ANIMALS live in a very different world from ours and their outlook on life must be totally different. There are good reasons for this opinion. Scientific studies have shown that the senses of animals—their sight, smell, hearing, and so on—are often quite unlike our own, and moreover that many animals have other senses which we can hardly imagine. Their windows for looking on life are thus quite different. Scientific research has also shown that the ways that animal minds function may be strangely remote from the workings of our own mind. So their world would certainly be very unfamiliar to us.

The world as the dog sees and smells it must be a strange one. It is probable that dogs are almost, if not quite, colour-blind, and so are most mammals or four-footed beasts, other than monkeys. Their surroundings are grey, not coloured like ours. But dogs have an exceptional sense of smell; their world is much more smelly than our world. And dogs have very good hearing: they hear higher notes than we do, and they can distinguish notes that are closer together. Moreover, the acuteness of their hearing is greater. For a human ear acuteness of hearing may be tested by means of a watch which is brought close to, or removed from, the ear. If the ticking is just loud enough for us to hear it at about four feet away, a dog can still hear the ticking forty feet off.

What the senses of many animals tell them may be very different from what our senses tell us. Instead of the colours red, yellow, green, blue and violet which we can see, a butterfly can distinguish only two colours, namely yellow and blue. Bees also see colours, but they cannot see red: it appears black to them. However, bees and butterflies can see an ultra-violet colour. We cannot even imagine this. Fishes, too, can see the ultra-violet colour, which is black to us. It is obvious that the world of butterflies, bees and fishes would appear very different to us if we had their eyes. Earthworms have no eyes at all, yet they notice light and darkness. If a worm is put in a dark room and then a light is shone on it, the worm wriggles. It perceives light although it has no eyes. We can scarcely imagine seeing the difference between light and darkness just through our skin. Incidentally, a Frenchman maintained in print not long ago that he could read the headlines of a newspaper through his skin when the paper was placed on his chest, but this has not been verified scientifically.

How different must be the world of fishes from our world, since fishes have a sense informing them when they are swimming towards a rock, thus enabling them to avoid collision even in darkness. Bats, too, when flying in the dark avoid obstacles; they feel their approach to anything solid, probably thanks to very sensitive skin on the face. One of the greatest mysteries in biology is how birds and mammals find their way home in unknown country, and how birds guide themselves on their long annual migrations, sometimes for distances as far as from Britain to South Africa and back. What are the clues they follow? What senses guide them? We do not know, but the animals may be able to perceive stimuli to which our senses do not react at all.

In our lives we distinguish thousands of different objects, and we usually recognize them wherever they may be, or in whatever circumstances we may see them.

Careful tests with animals have shown that this is not always the case for them. When a fly is caught in a spider's web it is at once attacked. Yet if a fly is put before the same spider away from its web, the fly is not attacked, but the spider rapidly moves away from the fly. Thus the fly appears quite different to the spider when seen on its web and away from it; the fly is only recognised as prey when seen together with the web. For us a fly is always a fly; not so for the spider.

The octopus lives in the sea and feeds on crabs, which it captures with the suckers on its arms and then quickly crunches with its powerful jaws. You might expect that a crab would be recognised by an octopus, which has very good sight, in whatever situation in the sea the crab was found, but this is not so. A hungry octopus pounces rapidly on a crab crawling on the ground, yet if a crab is dangled on the end of a string before the octopus, the latter does not move. But as soon as the crab reaches the ground the octopus jumps on it and envelops it with its tentacles.

If a bird's nest is moved a short distance while the parent birds are away, they look for it in its original position and they may completely ignore it in its new place, although they can see it well enough. They recognize the nest only in the setting of its original surroundings. One such experiment was made with a pair of martins. Their nest was moved only a few feet away and put in a conspicuous position. The birds looked for their nest in its old place, paid no attention to it in its new position, and next day started to build a new nest in the old place.

The same perception of a situation as a whole has been found in monkeys. A monkey was trained to find its food behind a door marked by a card with a red circle on it, and to take no notice of another door marked with a blue triangle. When the monkey had learnt this and made no mistakes, the blue triangle was changed for a blue circle. This completely confused the monkey; it no longer knew that its food was

behind the red circle. Evidently it had learnt the situation as a whole.

It is well known that if a bee-hive is shifted a few feet to the side, the returning bees mostly collect together at the old spot. Apparently the bees, too, see the situation as a whole. But this case is not quite so simple. For only the older, experienced bees are confused by the shifting of the hive; the young bees fly to the hive in its new position. The explanation of this, due to long and careful experiments, is as follows. On their first outings bees find their way back to their hive by sight, while later on the return becomes a habit and they fly back automatically to the same spot from which they set out. The seat of this automatic sense of direction is in the feelers or antennæ, and if their feelers are cut off, the older bees are no longer confused by shifting the hive. They are now bound to use their eyes, and they find the hive in its new place without difficulty.

Many animals which have good eyes, perhaps most, see situations as a whole and do not easily recognize objects out of their usual setting. We ourselves are just the same until we get to know a thing or a person well; often we do not recognize a casual acquaintance in unusual surroundings.

These examples show how different the senses and the working of the minds of animals may be from our sense organs and brain. Yet many people, perhaps most pet-lovers, will tell you that their favourite animals live in a world like their own, perhaps a smaller world, but a similar one. Scientific studies have shown that this cannot be so. The animal's world is not like ours, but it is a rich world, rich in other and unexpected ways. Consequently, the intelligence and the personality of animals, instead of being a miniature of the human model, is something quite different.

As to thoughts which animals may have, biologists can give no opinion. Many people will tell you what their cat or dog is thinking, but the scientist must be

more cautious. All we can say is that when the animal's brain is built something like our own, he may have thoughts like ours, even if much simpler. This applies to mammals, but in the bird's brain that part is not developed which we believe to be concerned with thought in our own brain. And the brains of all other animals are even more unlike ours. Insects have brains and these brains must function in a most complex way, particularly in the case of insects living in communities, such as bees and ants. But the structure of the insect's brain is so totally unlike ours that we can have no idea whether or not bees have thoughts while they are doing their many jobs inside and outside their hives, or whether they act like people walking in their sleep, without any thoughts at all.

Yesterday I read a statement in a daily paper which ran as follows: "Zebras often sleep standing up. A sound instinct, inherited from their wild forebears, makes them do this. A wild zebra knows that only by sleeping at the ready will he be able to make an instant get-away if a lion comes upon him." This is typical of statements made by members of the educated public. Yet it contains unwarranted assumptions. Leaving aside the question as to whether horses and zebras only truly sleep when lying down and just doze when standing, there is no evidence that the zebra knows why it sleeps on its feet. The newspaper writer correctly remarks that this particular mode of sleeping is an inherited instinct. This means that it is something which all animals of that particular kind do without having to learn how to do it. If the zebra knows the purpose which this instinct may serve in its life, we must suppose firstly that the animal can think and secondly that either it inherited the knowledge or acquired the knowledge from its parents or companions. Science advances by accepting the simplest possible explanations of phenomena. In the present case the simplest interpretation is that if the instinct of zebras to sleep standing does help them to escape from lions,

a reasonable though unproven assumption, then this instinct has arisen by the survival of the fittest zebras in the past history of the race. Those which slept in a dangerous way were wiped out by lions, thus leaving no offspring to perpetuate their bad habits. We have no means of knowing to what extent a zebra may have conscious thoughts, and even if it has any it is unlikely that an animal would realize the purpose of an instinct, as will be made clear in a later chapter on this topic. Nor is there any evidence that a zebra parent could communicate to its offspring the purpose of its instincts.

In the following chapters we shall be on sure scientific ground, and I am going to explain what the various strange senses of animals are like, what degree of intelligence animals possess and how their personalities are built up.

CHAPTER II

HOW ANIMALS COMMUNICATE

MANY animals are able to communicate with one another, although, of course, none of them can talk as we do. No animals use words. Yet they have got means of communication. Take birds, for example: a hen with chicks gives a warning noise and all her chicks crouch down motionless, until the mother makes another call which collects them together. Wild birds, when migrating at night, cry out; these cries perhaps keep the birds together. If one of the migrating birds strayed, it could hear the others and return to the flock.

We ourselves have more ways of communicating with one another than just by talking. When astonished, we may make an exclamation such as "Oh," and people around understand. If we don't care, we shrug our shoulders, and other people see and understand this movement. Animals cannot talk, they use no words or sentences, but some of them do make

noises corresponding to our exclamations of astonishment and so on. This is really what the mother hen does when she warns, or calls her chicks. The young jaguar in the picture on Plate II is crying out because she has been disturbed when she was alone; presumably her parents would understand her distress if they heard her. A horse neighs, or it paws the ground with its forefoot; that is, it makes a sound or a movement, and other horses hear the neighing, or they see the movement of pawing the ground, and this means something to them.

Not only sounds and movements but smells too are used by some animals to communicate with one another. Animals that live in herds, such as deer or the African elephants in the photograph on Plate II, which was taken from an aeroplane, must have some form of communication. Deer in a herd keep together partly by smell. When they eat grass, their noses leave a smell of deer on the ground, and their feet, too, leave a smell on the ground as they walk. Then any deer that is lost can probably find the others by following these scents. And everyone knows how dogs recognize one another by smell. Thus animals communicate by sounds, by movements and by smells.

Apes have many sounds, and many expressions of the face, which they make when they are apparently pleased or annoyed, hungry or content after a meal, and so on. Plate III shows two different expressions of a young gorilla. These various sounds and expressions on the face may be looked upon as part of the ape's language, in so far as other apes may understand them—although it has not been scientifically proved that actually they do understand them. Dogs bark, growl, snarl, whine and howl. And dogs also express their feelings by movements; they bare their teeth, lift a paw, their hair stands on end, and so on. Other dogs appear to understand these sounds and movements.

We ourselves have to learn how to talk, but babies do not learn to make cries of various sorts corresponding

to their feelings. Such cries of infants are not learnt but are made by instinct. This leads to a most important question. Does an ape, too, know how to make its various characteristic sounds and grimaces by inborn instinct, without any learning; or does it learn its "language" from its mother? This question has been answered by a Frenchman who kept an ape quite alone from its birth until it was five years old. For the first five years of its life this ape did not hear or see any other apes. The French investigator found that this animal was able to express itself in ape language just as well as any other ape of that species. All its cries and expressions were made by instinct; they had not been learnt. It is clear that the language of these animals had nothing in common with our speech; it resembles cries we may make such as "Oh!" and "Ah!" or shouting for joy, or weeping.

One would expect insects which live in societies, such as ants and bees, to be able to communicate with one another. Little is known about communication between ants (see the picture on Plate I), but quite a lot is now known about bees in this respect. Bees have a way of communicating with one another which they do not have to learn; that is, it is an instinct. But the bees' language is a very strange one; it is a language of smells and of dancing. When a worker bee, searching around in a field, finds a flower with sugary nectar in it, very soon afterwards many other bees are on the spot collecting the sweet liquid. How does the first bee, which has discovered the nectar, tell the others of the find? This has been found out by doing two things: by making hives with glass windows, and by marking bees with tiny spots of coloured paint so that separate bees can be recognized. In the investigation, as soon as a worker bee was observed in the act of discovering nectar, the scientist caught her, marked her with a coloured spot and freed her again. This enabled him to recognize the particular bee when she got back to the hive.

It was found that in the hive the bee first of all gives up the nectar she has brought back to another worker bee, who makes it into honey and stores it in a cell. Then the bee which discovered the nectar and brought it home begins to dance; she dances round and round. The effect of this dance is to induce other bees to join in and the first bee soon has a train of dancers behind her. Then, after a short time, the dancers fly off out of the hive and go to the flower which the first bee had found with nectar in it, and to other flowers of the same kind.

Evidently the dance is a means of communication: it informs the other bees that the first one has found nectar. But what is it that tells the bees in the hive where to go? How do they know where to find the flower with the nectar? For they do not follow the discoverer closely; each one flies out from the hive alone. The answer to this question is that the bees do not know in which direction to go. Once they have been told, by the dance, that nectar is to be had, they fly in all directions, some this way, others that way, until they find flowers with the nectar. The dance merely informs them that nectar is to be had in flowers of a certain kind. A few of the bees find the original flower; others find more flowers of the same species with nectar.

But how do the bees know in which kind of flower to suck the nectar? Somehow the discoverer has told them that the nectar is in this particular sort of flower. How was this done? It was done by scent; the first bee took some of the particular flower scent home on her body. The other bees smelt this scent during the dance, and this gave them the clue to the kind of flowers to visit.

This language of bees, like the language of apes, is an instinct; it is not learnt. All worker bees know it when they have reached a certain age, without being taught. Is this true also of the cries of birds? Here is an experiment which was made to test the matter.

Two hundred chicks were hatched in incubators. Half of these chicks were kept quite alone; the other half were kept alone, but they could hear cocks and hens near by. Both lots of chicks grew up. When they were big, they were all of them able to make various different kinds of sounds that cocks and hens make. Those chicks that had grown up quite alone could make the various sounds just as well as the others which had heard cocks and hens near them. Thus it appears that so far as the sounds made by birds are a means of communication, this language is an inborn instinct; birds do not learn it.

Yet there was one sound that the young cocks which had been brought up alone, away from other cocks, could not make as well as those which had listened to grown-up cocks: they could not crow properly. It appears, then, that crowing is not altogether an instinct; it has to be partly learnt. This is not really so surprising, because, of course, there are other birds which learn bird songs. Many birds can imitate the songs of other kinds of birds. A sparrow brought up with canaries makes a great effort to sing like a canary. If a canary is brought up with a nightingale it learns quite a good copy of a nightingale's song. So the whole of the song of birds is not instinct; some of it is learnt. Naturally, the best imitators among birds are parrots.

Can animals ever learn to understand our human language? Most pet-lovers would answer unhesitatingly in the affirmative. But usually a dog learns the tone of voice, not the actual words. If you say to a dog, in a cheerful voice: "I'm going to beat you," he will wag his tail. If you tell him, in a mournful tone: "I've got a bone for you," he will put his tail between his legs. But all the same, dogs can be trained to do things to words of command, and clever dogs will obey the commands when they cannot see the person speaking, and when the commands are given in an even tone of voice.

It is an interesting question whether wild animals

ever ask one another for something they desire, in whatever language they may possess. Some domestic animals learn from us to ask for what they want. A dog learns to beg for food; a cat learns to mew until a door is opened. Do any wild animals learn to express their desires to others of their kind in this way? Young animals may cry for food by inborn instinct, but as far as we know adult wild animals do not learn to beg. It looks as if domestic animals learn a sort of language that wild animals have not got.

The chief difference between the sound-language of animals and human language is that while an animal just expresses its feelings, we do more than that. We have words for things, and words for thoughts, and we make these words into sentences. With animals this is, of course, not so. If I take a banana away from a chimpanzee, he can show that he is angry; if he wants a banana, he can show that he is hungry; if he gets a banana, he can show that he is glad. His movements and expression indicate that he is angry, hungry or glad, even if they are made unwittingly. But the chimpanzee cannot say anything about a banana. Animals have no conversation.

Chapter III

WHAT SOME ANIMALS CAN HEAR

Most people think that fishes are deaf, but they are not. Biologists, too, until quite lately, thought that fishes were deaf. Now they know that fishes can hear quite well. Yet it is only in the last few years that this has been found out. It is true that years ago there was a certain monastery in Austria where the monks kept trout in a big pond. Each time a monk came to feed the trout, he rang a bell and the trout then swam towards the monk. People thought that the fishes heard the bell, until at last a biologist found out that the

trout came towards the monk in just the same way when he didn't ring the bell at all. The fishes really swam towards the monk because they saw him coming. So this does not show that fishes can hear. But it does show something else; it shows that fishes can be trained to do tricks. They can be trained just as circus animals can be trained, by giving them a reward of something to eat. What had really happened was that without knowing it the monk had trained the trout to swim towards him each time they saw him coming.

It is by training fishes that biologists have discovered, quite lately, that fishes can hear, and exactly what they can hear. Here is a typical experiment illustrating how this was done. A minnow was kept in an aquarium and each time that food was given to the fish a whistle was blown. The whistle was blown just before the food was given. At the sixth meal the minnow swam forward as soon as the whistle was blown, before the food was given to it. At the next thirty meals the fish always came forward as soon as the whistle was blown. The man who was making the experiment was hidden from the fish by a screen, and he stood quite still, so there is no doubt that the minnow actually heard the whistle; the fish had been really and truly trained to the sound of the whistle, for it was unable to see the man and the man did not shake the aquarium.

Thus minnows can really hear, and so can many other fishes. This has been proved in the same way as in the case of the minnows, by training them to sounds. Fishes have been trained to come not only to a whistle, but to the sound of musical instruments, for example a violin, and by this means a lot more has been found out about the sense of hearing of fishes. Here are some questions which have been studied. A human being can easily hear the difference between one note on the piano and the next note; can fishes hear this difference? Or can they only tell one note from another when the notes are further apart, for instance an octave?

To find this out minnows were trained to come to one end of an aquarium when one note was sounded, and to swim to the other end of the aquarium when another note was sounded. In this way it was demonstrated that fishes are able to distinguish two notes from one another only when the notes are about an octave apart; when notes closer together on the scale were used the fishes could not be trained to swim to one end of the aquarium in answer to one note, to the other end when the other note was played. Fishes thus have far less discrimination of notes than we have. But in another way the sense of hearing of fishes has been proved to be as good as our own; fishes can hear sounds which are so quiet that we ourselves can only just hear them.

But if they can hear such quiet sounds, how is it that fishes in a river are generally not frightened by shouting? The answer to this question seems to be that a shout has no importance at all for the fish. After all, a human being only moves if a sound means something to him, if it is a siren for instance; otherwise he takes no notice of it. All day long we are hearing sounds that do not disturb us at all because they mean nothing to us—for instance the continual noise of traffic outside in the street. In a scientific experiment a fish answers the sound to which it has been trained because that sound has been associated with food, but a fish may not move when you shout from the bank of the stream because that shout does not even mean danger to the fish.

Some people may wonder how it is that if fishes can hear we cannot see their ears. But the ears of birds are not visible either; the ears of birds and of fishes are hidden inside their heads. Others may think it strange that fishes can hear considering that apparently they have no voices, for few people have heard fishes making sounds. But, strange as it may seem, the truth is that many fishes do make noises, although the noises they make are not loud ones. Over fifty different kinds

of fishes are known to make sounds in the water. Even the minnow, when it is disturbed, makes faint squeaking and grunting noises. It is true that fishes have no organ of voice in their throats, yet they do make sounds. They accomplish it in the following manner. Most fishes have an air bladder in their body, which buoys them up in the water. Some fishes, gurnards for instance, have muscles on the walls of the air bladder which can make the bladder vibrate and so produce a grunting noise. Other fishes make sounds when the bases of the spines which form part of their fins creak or squeak in their bony sockets.

Now let us leave fishes and turn to dogs. How well can dogs hear? Most of us would like to know this, but the dog cannot be asked the question directly. The scientist asks the question by training a dog to musical notes, as the fishes were trained. But he goes about it in rather a different way. When a person is hungry and he sees a good dinner in front of him, his mouth waters. That is, saliva is produced by glands opening into the cavity of the mouth. Not only when a person sees a meal, but even if he only just smells it his mouth waters. Dogs are just the same: when a hungry dog sees or smells its food, the dog's mouth waters. It is this physiological process which has given biologists a way of finding out exactly what dogs can hear. For dogs can be trained so that their mouth waters when a musical note is sounded.

This is how it is done. A few seconds before a meal is given to a dog, a note is sounded. The sight and smell of the meal make the dog's mouth water. After 20 or 30 such meals the dog's mouth waters as soon as the note is sounded, before the food is seen or smelt. That is, the dog has been trained so that it produces saliva when a note is sounded. The investigator knows at once when the saliva is formed, because he has fixed a rubber tube into one corner of the dog's mouth. When the dog's mouth waters, the saliva drips out of the tube. He can also measure the

extent of the dog's response to a sound stimulus by measuring the actual volume of saliva produced; the saliva is allowed to drip into a measuring cylinder of glass. It may seem strange that we can train a dog's mouth to water; but we must remember that if a person is hungry, his mouth may water when he merely hears a dinner bell. As a result of many such occasions in the past, he has trained himself without knowing it.

With this technique of training the dog to salivate we have a way of finding out what notes a dog can hear. For suppose we train a dog so that its mouth waters when we play a certain note on the piano. Then, if we sound a different note, the dog's mouth does not water: no saliva drips down the tube. This means that, for the dog, the two notes are not the same; the second note does not mean a meal to the dog. If, however, the animal did salivate to the second note, this must have been because it could not distinguish the second note from the first. In this way biologists have discovered that dogs have a better sense of hearing than we have. Not only can dogs tell two notes apart which are placed next to one another on the piano; they can do much better than this. Dogs can distinguish between two notes which are only a quarter of the distance apart of two piano notes.

A simpler method than this has shown another important thing about the dog's sense of hearing. It has shown that dogs are considerably better than we are at locating the direction from which a sound comes. The tests were done in the following way. A dog was taught to sit at the centre of a circle of small cardboard screens, the radius of the circle being about 3 yards. The experimenter sat outside the circle, and by pressing an electric button he made a buzzing sound behind one or other of the screens, a different screen in each experiment. The dog had been taught to run to the sound, where a reward of food was to be found behind the screen. These experiments showed that a dog

could locate the sound from thirty-two possible sources, whereas a human being was not able to do this with accuracy out of sixteen possible directions.

In another way, too, dogs have better hearing than we have. If a person tries whistling higher and higher notes, in the end just a hiss is produced, which, of course, cannot be heard by another person from nearly as far off as a whistling sound. Dogs, however, can hear this hiss as a real whistling sound, for they can hear it from far away. There are whistles called Silent Dog Whistles, and with such a whistle you can train your dog to come to you when you blow a note which is too high for you yourself to hear. In some parts of the country poachers train their dogs to come to a whistling sound that they make with their lips, a sound which is too high for a man to hear.

As we know to our annoyance, many insects can make noises. One of the most irritating is the buzz of the mosquito or gnat. This sound probably has no meaning in the mosquito's life and is just incidental to the movement of the insect's wings. But other noisy insects have special organs for making sounds. Male long-horned grasshoppers, for instance, make their well-known noise or song, whatever one likes to call it, not in their throats but by very rapidly scraping a sort of file on a resonating membrane situated on the bases of their wing-covers. Since these insects have this rather elaborate apparatus for producing sounds, it is not surprising to learn that they can also hear. Their ears, however, are not where you might expect to find them; they are placed on the insects' fore-legs. Short-horned grasshoppers have their ears at the base of their abdomen (see the pictures on Plates IV and V).

Other insects have organs of hearing which are perhaps even more unexpected. Certain kinds of hairy caterpillars use their hairs to perceive sounds. Each hair is delicately hinged and when displaced by those pressure changes in the air which are sound waves the base of the hair presses on a minute nerve-ending. The

effects of noises on these hairy caterpillars have been studied. The insects respond to sounds either by raising their head or by becoming motionless when previously they were creeping. Spraying the caterpillars with water droplets or with flour deafens them; it clogs the motion of their hairs.

Here is one more remarkable case: the familiar cockroach or "black beetle" hears by means of feelers which can be seen sticking out from the hind end of its body. On these feelers there are microscopic hairs which are bent over by sound waves, thus pressing on tiny nerves. Minute as these nerves are, the electrical changes in them, which occur when the insect hears a sound, have actually been measured in recent scientific studies. This has been accomplished by amplifying these extremely small electrical effects with a similar technique to that used in wireless sets. By such means details of the cockroach's sense of hearing have been investigated.

CHAPTER IV

THE COLOURS THAT ANIMALS CAN SEE

WHAT colours can animals see? Is the world more brightly coloured or duller to animals than it is to us? To find out the answers to these questions scientists have used a method of training the animals to come to different colours, which is similar in principle to the method used in studying the sense of hearing of animals.

Let us take bees first of all, partly because more exact scientific research work has been done on the colour-sense of bees than of almost any other animal. It is especially interesting to know what colours bees can see because these insects visit flowers to get sweet nectar from them to make honey, and in so doing the

bees incidentally carry pollen from flower to flower. On the face of it, it would seem very likely that bees are attracted to flowers by their bright colours. But possibly it is the scents that attract the bees, or perhaps it is both colour and scent. So, among other things, we want to know whether bees can really see the colours of flowers, and, if so, what colours they can see. Exactly how is this found out?

A table is put in a garden, and on the table a piece of blue cardboard is placed, on which there is a watch-glass containing a drop of syrup. After a short while bees come to the syrup and suck up some of it. The bees then fly to their hive and give the syrup to other bees in the hive to make honey. Then they return to the feeding-place which they have discovered. We let the bees go on doing this for a while, after which we take away the blue cardboard with the syrup on it. Instead of this card we now put on the table a blue card on the left side of the first feeding-place, and a red card to the right of the first feeding-place. These new cards have no syrup on them but only an empty watch-glass lying on each. Thus, the blue card is on the left, the red card on the right, and there is nothing where the first blue feeding-card used to be. After we have arranged these new cards, we have not long to wait. Very soon bees arrive again, and it can be seen that they fly straight on to the blue card; none go to the red card.

This behaviour of the bees seems to indicate two things. The first is that the bees remember that blue means syrup and so they fly to the blue. Since they did not go to the place on the table where the syrup used to be, but flew to the blue card which had been placed on the left, it really was the blue card that attracted them, not the place where the syrup had previously been. We have trained the bees to come to the blue card. And the second thing our experiment seems to mean is that bees can tell blue from red.

But can they? This is not yet quite certain. The

reason for our doubt is as follows. It is well known that there are a few people in the world, very few, who cannot see colours at all. These people are totally colour-blind. To them the whole world looks as if you or I saw it through a grey glass; all colours look like different shades of grey. Through a grey glass you might be able to tell red from blue, because red would perhaps look darker and blue lighter in shade, but they would not be red or blue. It might be, then, that bees are really colour-blind, and that in the experiment they came to the blue card not because they saw it as blue but just because it appeared lighter in shade than the red card. Perhaps they had really been trained to come not to blue, but to the lighter of two shades. We can find out quite simply if this is so by another training experiment.

On our table in the garden we put a blue card, and all around this blue card we put a number of different grey cards. These grey cards are of all possible shades of grey, from the extremes of white to black. On each card a watch-glass is placed. The watch-glass on the blue card has some syrup in it, all the others are empty. After a short time bees find the syrup as before, and they come for it again and again. Then, after some hours, we take away the watch-glass of syrup which was on the blue card and put an empty one in its place. Now what do the bees do? They still go straight to the blue card, although there is no syrup there. They do not go to any of the grey cards, in spite of the fact that one of the grey cards is of exactly the same brightness as the blue card. Thus the bees do not mistake any shade of grey for blue. In this way we have proved that they really do see blue as a colour.

We can find out in just the same way what other colours bees can see. It turns out that bees see various colours, but these insects differ from us as regards their colour-sense in two very interesting ways. Suppose we train bees to come to a red card, and having done so we put the red card on the table in the garden

certain different colours, just as they were trained so that their mouth watered when definite musical notes were sounded. Such experiments have turned out failures; it has been found impossible to make dogs distinguish colours from one another as signals for their dinner. This question requires further testing with other techniques, but so far as the available scientific evidence goes, dogs seem to be colour-blind. Many dog-owners will disagree with this, being convinced that their dogs know, for instance, the colour of a dress. But the evidence given for this has never been sufficiently rigid for a scientist, who is not certain that the dog did not really respond to some other clue or sign than the colour—to a smell, for instance, or to the particular behaviour of the wearer of the dress.

Experiments have been made, too, to test the colour-sense of cats; although these experiments may not yet be conclusive, they have indicated, so far, that cats are colour-blind. Different cats were trained to come for their food in response to signals of each of six different colours. But the cats always confused their particular colour with one of a number of shades of grey, when these were offered at the same time as the colour.

Monkeys, on the other hand, are able to distinguish colours. They have been trained successfully to go for their meal to a cupboard, the door of which was painted in a certain colour, and to ignore other available cupboards with differently coloured doors, in which there was no food. Apart from monkeys and apes, however, most mammals seem to be colour-blind, at any rate those which have been scientifically tested. Even bulls have been shown not to see red as a colour. In spite of popular belief they are not excited by red, and they cannot distinguish red from dark grey. No doubt any bright waving cloth excites a high-spirited bull.

Colour-blindness in mammals, other than monkeys, is comprehensible when one considers the lives of the animals in a wild state. For nearly all wild mammals

are nocturnal or crepuscular. Wolves and lions hunt mostly at night, while antelopes and wild cattle graze at night, or in the evening when there are few colours. But monkeys, in the forests where they live, are awake and about in the daytime, and there are abundant colours for them to see in the bright tropical light.

Moreover, the colour-blindness of mammals other than monkeys accords with the fact that the animals themselves are all more or less dull coloured; their coats are brown or yellow, black or white. Only in monkeys are greens, bright reds and blues found. These are colours which recall the brilliant tints of birds and of fishes, animals which also possess colour-vision.

CHAPTER V

STRANGE SENSES

MANY animals have a very delicate sense of smell; they can detect things that we are quite unable to smell. This is obvious enough when one watches a dog hunting: the dog follows a scent on the ground which we certainly could not smell. A dog may follow its master's scent without hesitation in a crowd of other people. Some dogs are trained for police work. Such a dog, when it is set to follow a person, can smell an object which the person has touched for only a few seconds, and later on can pick out this object from among other things. When dogs are tracking across country, they make use of another smell besides that of their quarry: they follow the smell of crushed grass, of grass crushed by the feet of the quarry, which is a scent unnoticeable to us.

Smell is much more important than sight in the lives of dogs, and this is true not only of dogs but of most

mammals. Most four-footed beasts have an acute sense of smell, while they have rather poor eyesight. For birds the opposite is true; they specialize in sight at the expense of smell.

There are other animals, besides mammals, which have a very delicate sense of smell, moths for instance. Insects, incidentally, smell with their feelers or antennæ, not with a nose. In moths the males are attracted to the females by smell. That is how they find their mates, but the scent of the female even of a large moth is so faint that we cannot smell it at all. Yet if a female of certain species is put in a matchbox at an open window, males of the same kind of moth fly to her. Before long a number of the males may be fluttering around the window, and many of them will have come from hundreds of yards away. Many animals besides moths find their mates by smell. One has but to think of a chorus of tomcats at night; the toms have been attracted to a female puss by her scent.

Bees visit flowers to get nectar for making honey, and they also carry home pollen to the hive for their food stores. Flowers which attract the bees are coloured, and they are also scented. It is therefore interesting to know which it is that attracts bees to the flowers, their colours or their scents. Bees can see colours, as we know from the last chapter: can they also smell the flower scents from a distance? To find this out biologists have trained bees to come to scents. Little boxes were used, placed in a row out in a field. Each box had a hole in it. One of the boxes was coloured, say, yellow, while the other boxes were white. Inside the yellow box a sugary liquid was put, while the other boxes were empty. Before long, bees discovered the sugar and they soon learnt to fly to the yellow box. They continued to fly to this box after the sugar had been removed from it. They had been trained to come to the yellow colour.

Then another experiment was made. This time all the boxes were white, but one of them had a scent in

it, for instance rose scent. This box, with the scent, also had the sugary liquid inside it, but none of the other boxes had any syrup in them. The bees soon learnt to come for the sugar to the scented box. And now we come to the most interesting part of the experiments. The investigator wanted to know whether bees recognize flowers by their colours or by their scents. He had trained the same bees to come to a yellow colour and to a rose scent. Having done this he arranged his boxes (without any sugar) so that one was coloured yellow but was scentless, another had rose scent in it but was white, while all the remaining boxes were scentless and white. Which box did the bees fly to? Coming from a distance, they flew towards the yellow box, but when they got near it they turned away and went to the rose-scented box. This means that bees know flowers from a distance by their colours, but when they get near they know the flowers by their scents. Of course, the experiments were, as usual, repeated many times before the scientist felt sure of his conclusions.

Most mammals have not got as good eyesight as we have, and certainly their sight is far less keen than that of the hawk and many other birds. Still, mammals do of course use their eyes. We ourselves have got binocular vision. That is, we bring both our eyes to bear on an object and we see the object from slightly different angles with the two eyes. This helps to give the effect of solidity. The same is true of certain mammals besides ourselves—monkeys, dogs and cats for instance. But others only use their two eyes when the object is in front of them. When it is to one side of the head, the thing is looked at with one eye only. Horses use a single eye like this, and so do deer and rabbits. These, in nature, are hunted animals, not hunters. The eyes placed wide apart, one on each side of the head, must give the hunted animals a wider field of vision to detect the enemy; the precision and solidity of binocular vision is sacrificed for safety.

Fishes, lizards such as the chameleon, and birds, are able to move each eye independently; this seems very strange to us who cannot do it.

Cats are much better at seeing in the black-out than we are. Yet our eyes, like those of other animals, do adapt themselves to different light intensities. One of the ways in which this is done is by a change in the width of the pupil or aperture through which light enters the eye. In bright light the pupil becomes narrower, in dim light it widens and lets in more light. The changes are quite automatic; they are automatic reflexes and are surprisingly rapid. Very few people have seen the pupil of an eye change. Here is a most amusing way of showing it. In a room with ordinary daylight or artificial light, ask a friend to look closely at the pupil of one of your eyes. Point a flashlamp at your eye and, while your friend is looking at your pupil, switch on the lamp. He will certainly be astonished at the immediate result of this. You can astonish him still more by getting him to look at, say, your right eye, and, while he is doing this, shining the flash-lamp into your left eye, at the same time holding a book in front of your nose so that the lamp cannot shine on to the right eye.

The pupils of the eyes of dogs and cats are wide open at night. It is partly for this reason that their eyes shine in the glare of your headlights, whose light is reflected back from inside the animal's eyes, concentrated by the eye lenses. It may appear to you that there is a light within the animal's eyes, but this is not so. The glow is all due to external light reflected back from inside the eye. Very occasionally human eyes shine in the same way with reflected light at night.

Besides seeing, hearing and smelling, we may ask what other senses animals have got. We ourselves are supposed to have five senses. These five are sight, with our eyes; hearing, with our ears; smell, with the nose; taste, with the tongue; and touch, with the skin. But really we possess more senses than these five. We

know, for instance, if it is a hot day or a cold day; we know if we touch something hot or cold. So we must have a sense of temperature. Actually we have separate microscopic nerve-endings in the skin for telling us if something touched is hot or is cold. If the skin of a blindfolded person is touched at various points close together with a hot needle, only some of the points touched will detect the heat. These endings of nerves detecting heat can be marked on the skin with ink. If the same patch of skin is then explored with a cold needle, the cold sensation is felt at different points from those marked with ink. Pressure of a needle on the skin is felt at still other points.

Suppose you shut your eyes and turn round; you know which way you have turned. It is actually a part of your ear that tells you which way you have turned, a part of your ear which has nothing to do with hearing. If you spin round quickly, you get giddy. This is because the part of your ear that tells you which way you turn cannot do its work properly if you turn too fast; it goes out of order for the moment. Then you don't know where you are: you are giddy. Naturally you can tell which way up you are: you know if you are standing on your feet or on your head. Again it is a mechanism in your ear that helps to tell you this. If you shut your eyes and move an arm, you know which way you have moved your arm, although you cannot see it; there are sensory nerves from your limbs that tell your brain which way your limbs move. So it is clear that we have at least four other senses besides the five that everybody knows about. We have a sense of temperature, a sense of turning the body, a sense of which way up we are, and a sense of moving our limbs.

Fishes have got yet another sense, which we have not got at all. Many people will have noticed that fishes have a line running down each side of the body. All along this line on the side of the fish there are tiny organs which tell the fish when it is swimming towards

a rock. This is what happens: if the fish swims towards any solid object such as a rock, the water presses against the fish. The line on the fish's side has microscopic organs in it which detect this pressure of the water. Thanks to the information supplied by these organs the fish can turn aside and so avoid hitting rocks, even in the dark.

Thus many animals, fishes for instance, have senses that we have not got at all. Here is another case. It concerns bats, which are flying mammals. There is an unusually good photograph of a bat in flight on Plate VII. Bats are able to fly at night without hitting anything, even if they are flying in darkness. It is very remarkable how bats can avoid things in the dark. An ingenious way of testing this was first devised in the seventeenth century by Spallanzani, a remarkable Italian who made experiments with animals long before other scientists started to do so. He hung a number of strings from the ceiling of a room. At the end of each string was a little bell. The room was in complete darkness. Then a bat was let loose in the room. The bat flew about, but hardly rang any of the bells attached to the strings. What is the explanation? We ourselves feel wind on our cheeks. The skin on a bat's face is perhaps very much more sensitive than our skin, so sensitive that a bat would feel the pressure of the air when flying towards anything solid. This might be the case, but the following seems a more likely explanation. Bats are known to squeak, their notes being sometimes too high for human beings to hear. Perhaps the echo of these squeaks from the strings are heard by the bats, warning them to keep off. Echos of such ultrasounds are used in depth surveying at sea.

In conclusion, here is a mysterious case of a certain kind of insect. It is called an ichneumon, and is a relation of bees and wasps, although much smaller. Now, there is another kind of insect, the so-called wood-wasp, whose young, or grubs, bore into the trunks of trees. They harm pine trees with their tunnels. The

ichneumon is the enemy of these wood-boring grubs, for it lays its eggs on them and its young eat the wasp grubs. The ichneumon alights on the tree and makes a hole through the wood with two minute needles, like tiny saws, which are attached to the hind end of its body. The ichneumon works these needle-saws up and down very fast, and in about twenty minutes the instruments pierce the wood right down to the grub. Then a very small tube on the tail end of the insect goes down into the hole in the wood and through it an egg is laid on the wasp grub. The young ichneumon which later on comes out of this egg will slowly eat up the grub. Our problem is this: how does the ichneumon find the grub which is inside the wood? Can it smell the grub through the wood? If so, its delicacy of scent must be extraordinary. Or can it tell by the touch of its feelers that the wood is hollow? This too would be a remarkable achievement. Or has the ichneumon another unsuspected sense? We do not know.

CHAPTER VI

PLAY

MANY animals play, particularly young animals. Playful kittens and puppies are familiar to all, and other domestic animals play as well. Lambs gambol, and so do kids; foals frisk round their mothers. Wild animals also play. Plate VI shows lion cubs playing with their parents, and on Plate VIII there is a photograph of bear cubs at play. Play is so familiar in children and in young animals that most people never ask themselves whether play is of any use to the animal. But the scientist does ask this question; the biologist wants to know if there is any purpose in play. Most actions of animals are of use to them; is play useful

to the growing animal, or does the animal merely play because it has got too much energy? Does it just play to let off steam?

Before trying to answer this question, let us see first of all what kinds of animals do play. The animals already mentioned which play when they are young are cats, dogs and lions, sheep, goats and horses. These are all mammals. Do other animals besides mammals play? Do frogs play, or insects, or crabs? The answer is no; mammals play, but fishes and insects can hardly be said to do so. And what about birds? Some birds may perhaps play, but young birds do not play like puppies and kittens.

If one thinks about the play of puppies and kittens, it is clear that their games are of two kinds; they play at fighting and at hunting. Everyone has seen a kitten patting a cork or a ball, making it roll, and then pouncing on it. The kitten is doing with the cork what it will do later on with a mouse; it seems to be playing at hunting. A puppy will catch hold of anything it can find with its teeth, and if possible tear it to bits. The puppy is apparently playing at killing its prey. This gives us a clue to what may be the usefulness of play to the kitten or the puppy; by playing, the young animal can learn its job of hunting. By playing, it is gradually becoming more skilful. For young cats have actually got to learn how to hunt. They begin to learn by playing, and also their parents help them. Cats bring half-killed mice to their young to play with. There is a picture of this on Plate VIII; you can see what looks like a watchful expression on the face of the mother cat while her kitten plays with the mouse. Weasels and stoats bring wounded prey to their young in the same way; the young play with it and learn. Later on, parent animals take their young with them on hunting expeditions. Lion cubs accompany their parents in the search for food until they grow up, and thus they learn the arts of seeking cover, making the final spring and dispatching the victim.

Kittens and puppies also play at fighting. Everybody has seen their tussles and squabbles and playful fights, and knows that the puppies never hurt each other. They pretend to use their teeth, but there is no biting. The kittens don't use their claws. They are apparently just practising attacking enemies and defending themselves; they seem to be learning by practice. The cubs of lions, tigers and bears play at fighting in the same way, and sometimes their parents join in. Kids butt one another before their horns grow, and so do young deer before any antlers appear.

It goes without saying that the kittens or puppies cannot know that their play may teach them the serious jobs of hunting and fighting which they will need later on, or at least which they would need if they were living a wild life, not a domestic one. They cannot realize this; they are just born with instincts to play at hunting and fighting. In addition to destroying things and pretending to fight, lion cubs and puppies are very inquisitive. They are curious about all manner of things. Surely this, too, is a part of their training for grown-up life; they must be learning to follow a scent and track their prey.

Thus it seems very probable that play is useful to these young animals; by playing they get skill in hunting, tracking and fighting. But play also helps them to do simpler things: it helps them merely to move properly. One of the charms of a puppy is its awkwardness; at first it can hardly stand or run. The puppy has to learn to walk, just as a baby has to learn to walk, and play must help the young animal to practise moving properly. Both kittens and baby monkeys try climbing early in their lives. They have not much success at first, but gradually, by playing, they become skilful at climbing. Young birds play no games like puppies or kittens, but many kinds of birds have to learn to fly. They cannot fly perfectly at first; they learn skill in flying in repeatedly trying.

There are certain kinds of mammals which play very

little when they are young. These animals do not learn their jobs in life by playing. Like birds, they know most of their jobs by inborn instinct. Take squirrels, for instance. Squirrels collect nuts and seeds and make stores of them for the winter. Squirrels do not learn to do this ; it is an instinct. They inherit the knowledge of how to do it from their parents. Squirrels are rodents; they belong to the same family of mammals as rabbits, guinea-pigs and mice. None of these animals play much when they are young. It is the flesh-eating mammals, the cats and dogs, which play most when young and so educate themselves. The same is true of monkeys. Play educates those mammals which do not know their jobs in life by instinct.

Among ourselves it is not only children that play. Grown-up men and women play too; they have their games and sports. And it is not only during infancy that animals play. Polar bears may be seen playing together at the Zoo. Those that play are perhaps still young, but they are no longer cubs. And fully grown dogs play. When a kitten grows up to be a cat, you don't often see it play, but it does still keep at least one game: when a cat catches a mouse it plays with the mouse before killing it. Now, why should grown-up animals play? This cannot help them to learn their jobs; they have learnt them already. It seems more probable that grown-up animals play when they have got too much energy. If a horse is given lots of corn and not enough exercise, we say that it is fresh. The horse is really playing; it is just using up surplus energy.

Of course, part of the reason for young animals playing is just the same: they are so full of life. Lambs, kids and foals jump about just as children skip along the street instead of merely walking. Yet surplus energy is not the only reason why young animals play. For a kitten rushes after a moving bit of paper even if it is tired out with long playing. Puppies play together until they are exhausted and lie down with their tongues

hanging out; then one gets up and seizes the leg of the other, and they start off again. The young can go on playing after all their surplus energy is gone.

It is conceivable that one reason for play in fully grown animals is a mere pleasure in bodily movement. This may well be why polar bears plunge and splash in the water in a zoo, and why apes occupy themselves with a swing or with some tool that they have found. Perhaps animals sometimes even play for the pleasure they get from doing something which is difficult, although I am not for a moment assuming that they would consciously realize this. People who train dogs to perform somersaults on the stage know that often the dog goes on and on turning somersaults after it should have ceased. This looks as if the dog continued the play because it enjoyed it. Here is another case. In winter, rooks have been seen to fly up high in the air and then fold their wings and drop down. They whiz down, and only open their wings, and use them as brakes, when they are near the ground. Then the birds skid and swerve, and finally land. Rooks will do this again and again. It certainly looks like a sport; it looks like the thrill of a violent sensation. But this, of course, is speculation.

In conclusion, here is an account of a game that certain chimpanzees were once seen to indulge in. This is more complicated than the play of other animals, but then chimps are more like ourselves. The chimpanzees were in a cage placed out of doors, and there were some hens living in the yard outside the cage. A chimp would sit near the bars of the cage, eating bread. From time to time he would hold out the bread in his hand to a hen, and then when she pecked at it he would pull the bread back again. But, better than this, two of the chimps combined to have a game together. One held out bread to the hen, and when she came to peck, the other chimp poked her with a stick. This was a game which the apes themselves had invented.

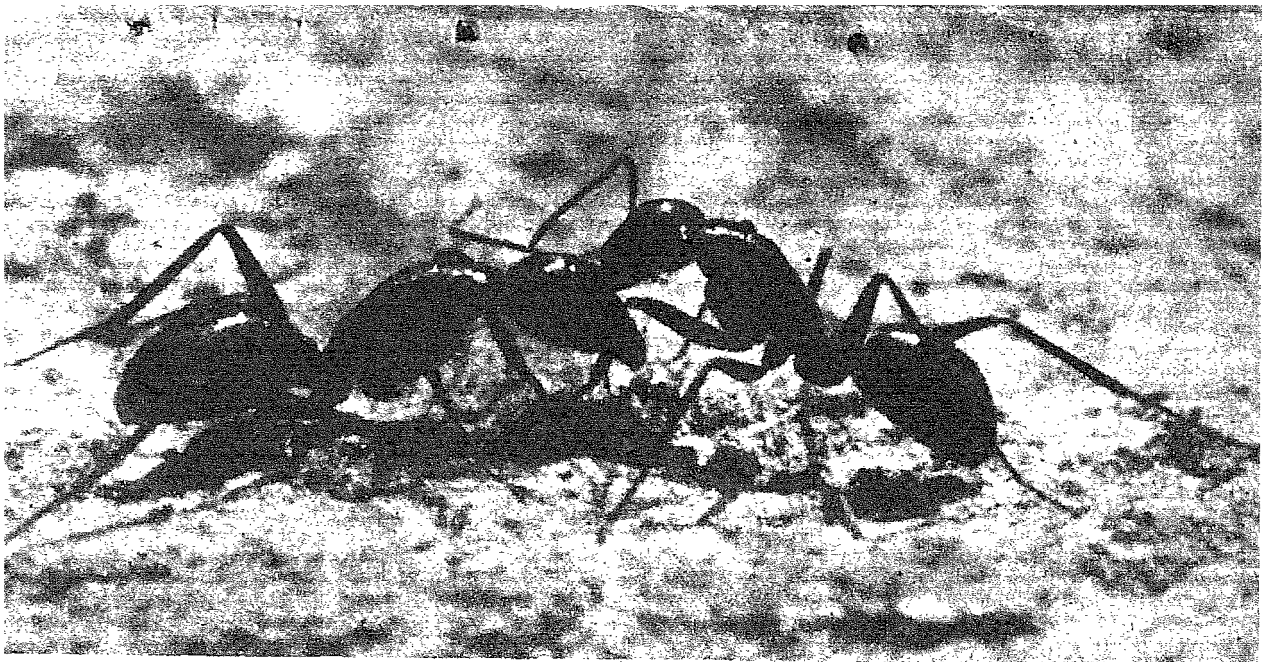
Chapter VII

WHY DO BIRDS BREED IN THE SPRING?

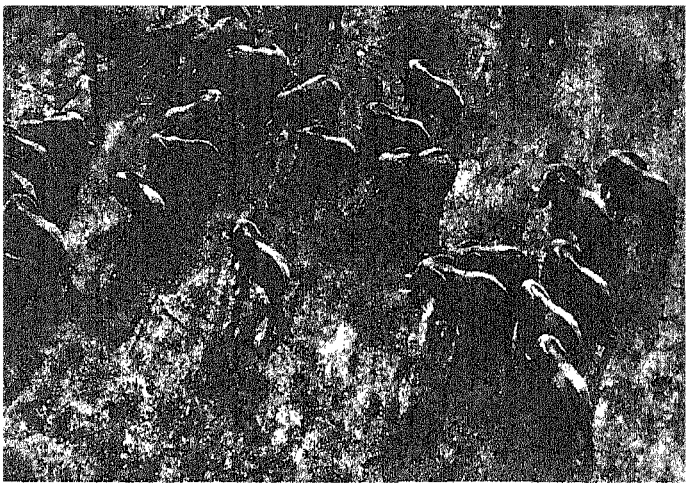
Very many wild animals have families in the spring. Tadpoles appear in spring. Birds make their nests in spring. Wild rabbits breed from February to May. Foxes usually mate in January and the cubs are generally born in March. There are very few wild animals which have young in autumn, and one may well ask the reason for this. Why do most wild animals—frogs, birds and mammals—breed in spring?

Before trying to answer this question it is important to remember that while in fact most wild animals have their families in the spring, yet preparation for breeding begins much earlier. Take the case of birds. A pair of birds build a nest in the spring. The birds mate. The hen lays eggs. The parents sit on the eggs to keep them warm until they hatch. Then the young are fed by the parent birds until they can fly. These are the main events in the breeding of wild birds which are familiar to everyone, but it is not so well known that a number of preliminary events, sometimes of long duration, take place before the birds begin to build a nest.

This is how robins go about it. The story of how robins breed starts, not in spring, but in the summer of the year before. Towards the end of August each cock bird takes possession of a piece of land. It may be a field or part of a wood; it is usually about an acre in extent. The cock will not allow any other robin on his territory, and if another one trespasses our robin chases him away. But there is seldom a real fight; usually the particular robin who is the owner of the land frightens the invader by showing him his red breast, and rarely does the invader put up a fight. Our robin, when he is not feeding, or sleeping, or frightening or chasing an intruder, sits on a tree and sings. This tells all other robins within earshot that



I Ants : A fight or a discussion? (Chap. 2) *Mondiale*

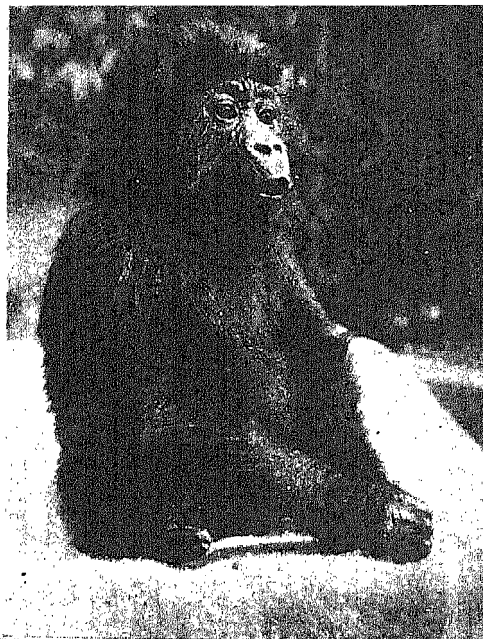


How do elephants in a herd communicate? (Chap. 2) *Popper*

II



Baby jaguar saying that she is annoyed. (Chap. 2) *Daily Mirror*

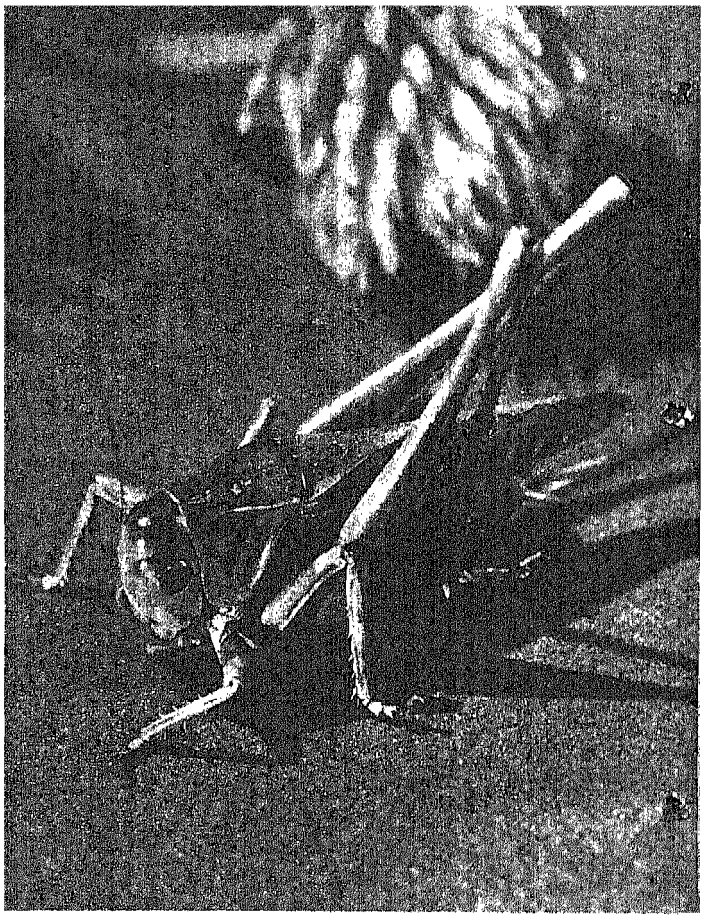




Young gorilla: What do his expressions mean? (Chap. 2)

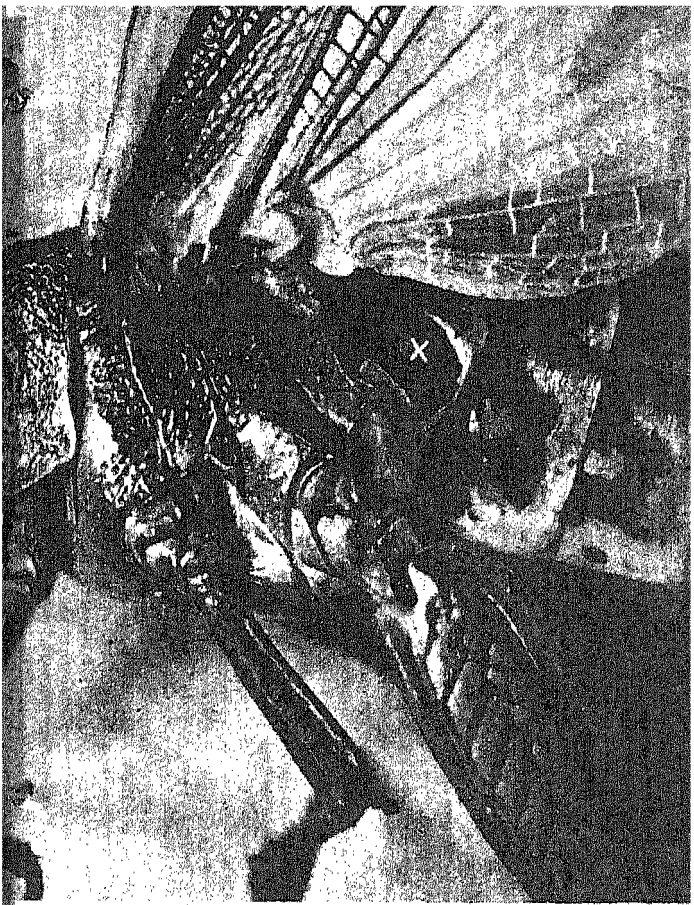
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III



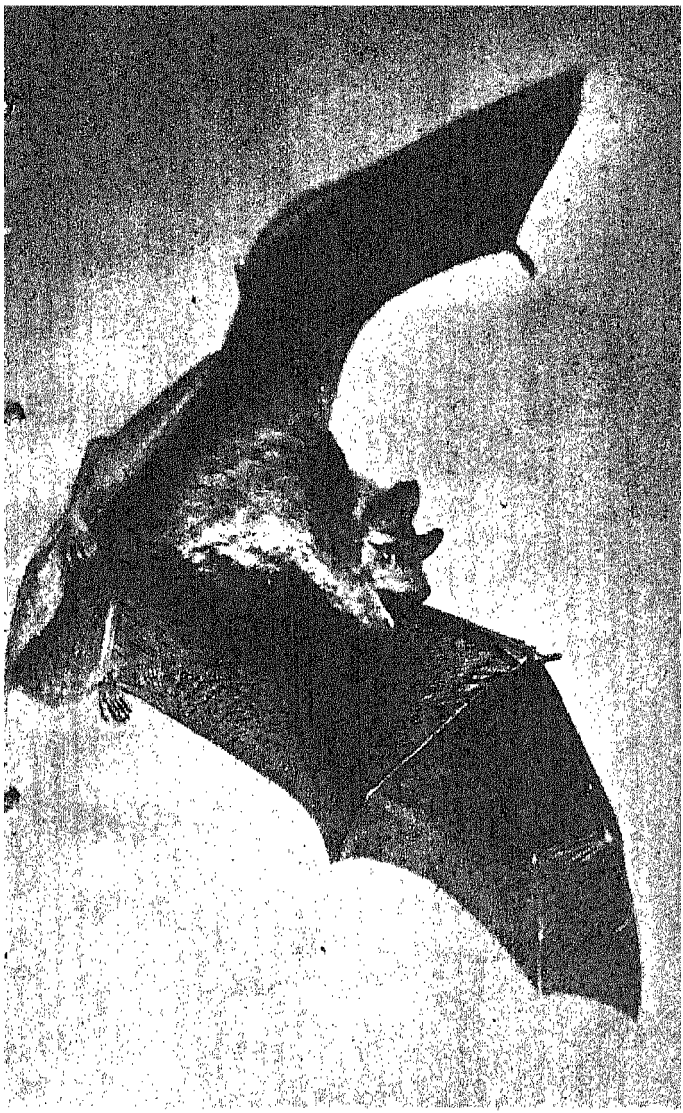
Fox Photos

A grasshopper has strange ways of singing and hearing. (Chap. 3)



Grasshopper's ear, marked by the cross. (Chap. 3)

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H. E. Edgerton

VII

The bat avoids obstacles even when flying in darkness. (Chap. 5)

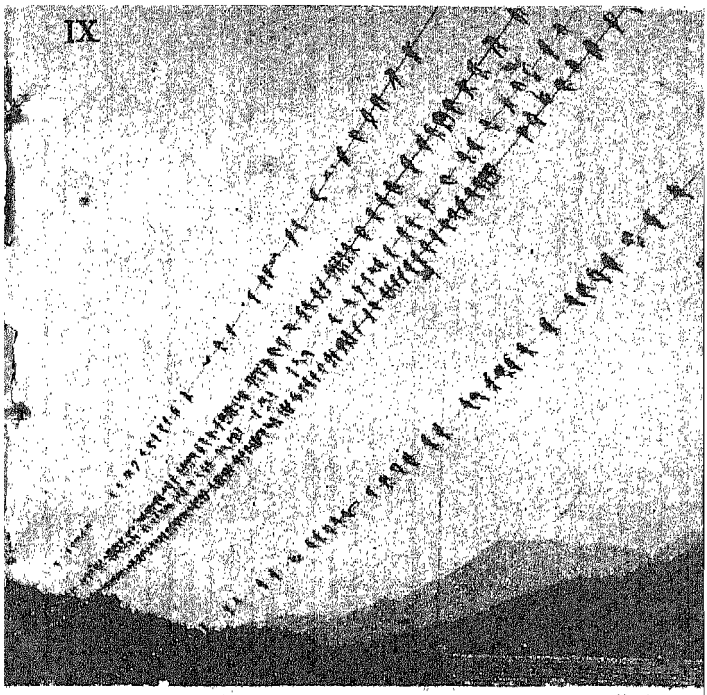


Cat watching her kitten playing with a mouse. (Chap. 6)
Evening Standard

VIII

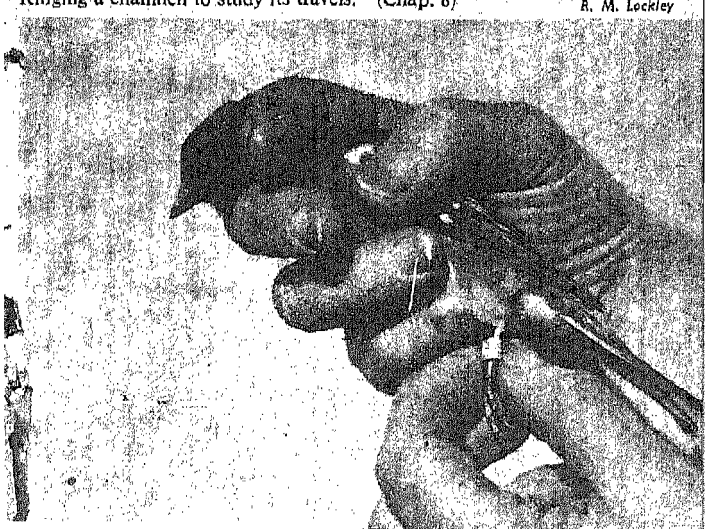


Playful bear cubs. (Chap. 6)
Planet News



Swallows assembling for their southward migration. (Chap. 8) *Mondiale*

Ringing a chaffinch to study its travels. (Chap. 8) *R. M. Lockley*

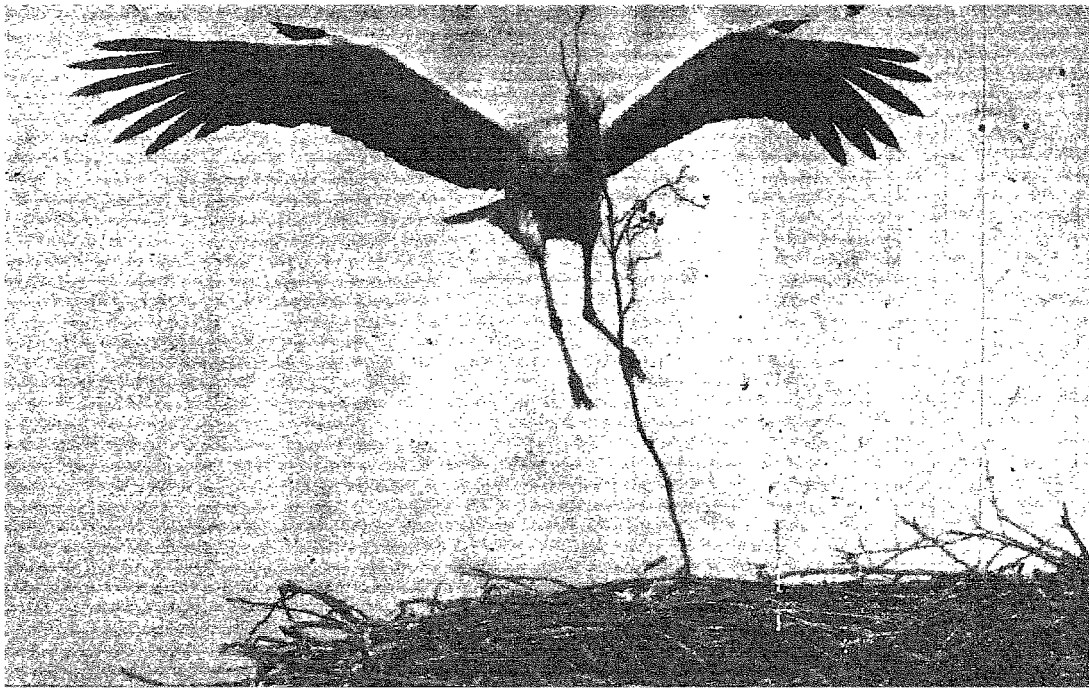


X

Start of a pigeon race (Chap. 9)



Fox Photo



XI

Stork building i
nest. (Chap. 12.

Mondial

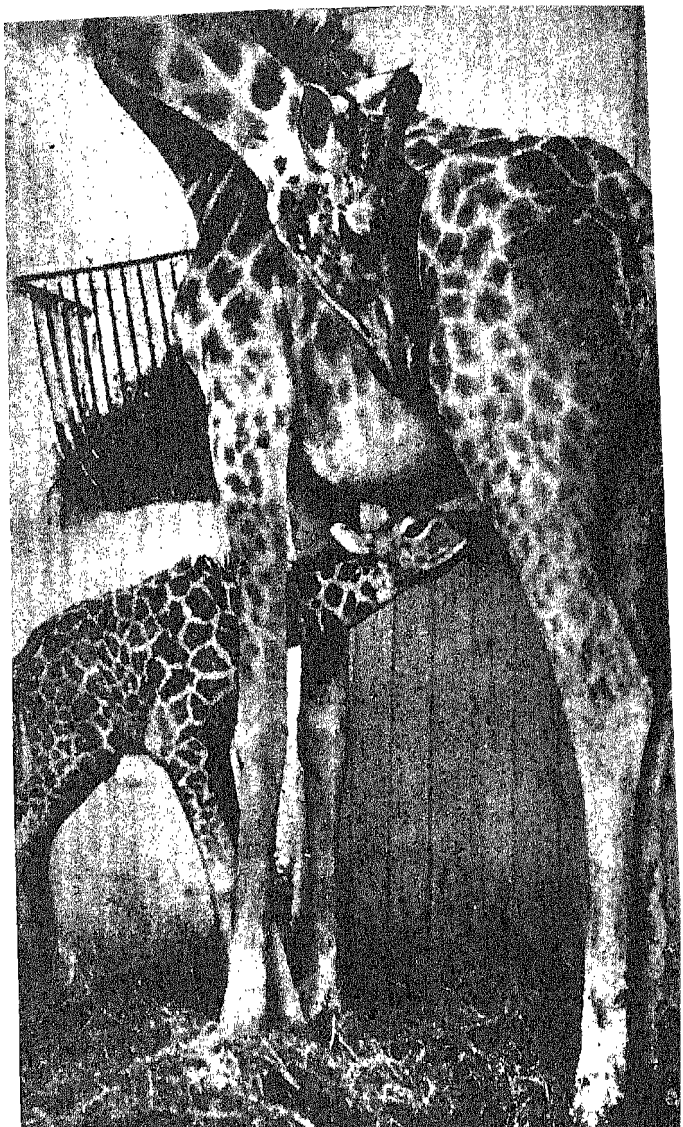


Baboons : Father, mother and infant. (Chap. 11)



Daily M

Strange friendship between cat and rabbit. (Chap. 12)



XIV Baby giraffe and mother. (Chap. 12) Daily Mirror

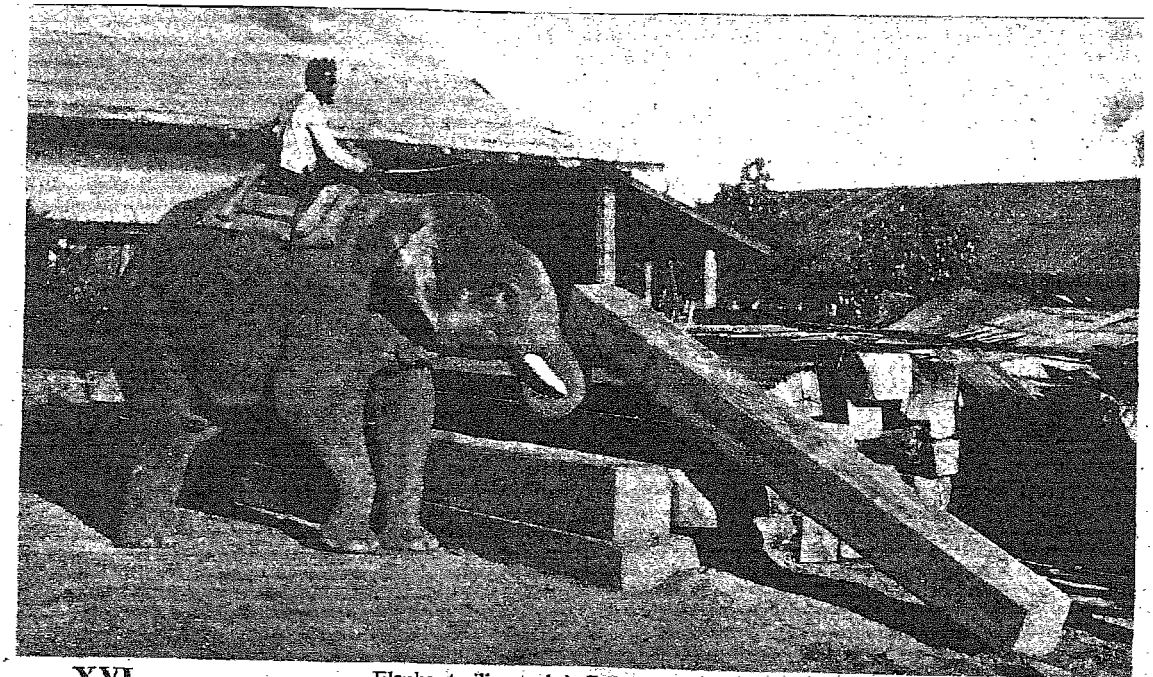


Mondiale

Young cuckoo asking for food from its meadow pipit foster-mother. (Chap. 12)

Mother bear carrying her cub by the head. (Chap. 12) Fox Photos





XVI Elephant piling teak in Burmah. (Chap. 13) Popper

this particular piece of land is his. But he doesn't hesitate to invade his neighbour's territory for food, although if his neighbour then threatens him, he prudently retreats. From August until December or January each cock is alone on his special bit of land. Then each one is joined by a hen bird, who becomes his wife for the next six months. She has found him by hearing his song. From New Year onwards they live together on his land, but it is not until the end of March that nest-building begins. Then cock and hen mate and the young hatch out in April and May, for each pair of robins has more than one brood. Thus many things occur before the actual breeding takes place.

All these facts about robins—their territory, how they frighten enemies, how they pair, and much more besides—has been found out by ornithologists patiently watching the birds, particularly birds which have been caught once and on whose legs differently coloured rings of celluloid have been put, so that the individuals can be recognized when they are watched through field-glasses.

We started by asking why wild animals breed in the spring. Why do robins and other birds nest in spring? The reader will think at once of an answer to this question: the young birds are hatched in spring because the weather then is best for them. It is warm, the days are lengthening, there is plenty of food, the summer days are ahead for the young birds to get strong. The same thing must be true for other birds.

Robins are birds which spend the winter in England, but there are birds which go to warmer countries for the winter. Some fly to Africa. Nightingales do this, and swallows and cuckoos. These birds come back from Africa in the spring. When the nightingales return to England in the spring, each cock bird takes possession of a piece of land, and gets up into a tree and sings his lovely song, advertising to other nightingales that he is lord of that territory and is ready for a

mate. After a hen-bird has joined him, they raise families like the robins. Again it may be said that they do this in spring because spring is the best season for their young.

The same is true for other animals. Deer mate in the autumn. The stags first fight one another with their antlers. The strongest stags win, and they become the fathers of the families to come. This happens in autumn; the stags mate with the hinds in autumn and the young are born next spring, again in the best season of the year for the young. Mating of deer must take place long before the young are born, for deer require a long time to develop in the womb.

Thus we may say of birds and of deer, of foxes and of wild rabbits, that they have their young in spring because spring is the best season for the young to be born, and the parents start preparations for a family just so long beforehand as is necessary for the young to arrive in spring. But this is only one possible answer to our question. It is only one possible answer because every question about animals has two quite different kinds of answer to it. If we are asked why does an animal do this or that, we may answer: because it is useful to the animal. The animal breeds in spring because spring is the best season for the family to begin life. But besides this answer the scientist also requires a totally different kind of answer. He wants to know exactly *how* the animal does whatever it may be. In the case we are considering he wants to know precisely what it is that gives the signal to an animal that it is time for it to breed, and what actually occurs inside the animal's brain and blood, leading up to the process of breeding. The scientist asks himself first of all whether birds get the signal to pair and start nest-building owing to the weather being warmer in spring, or because the days are getting longer, or for some other reason.

What is it that gives birds the sign to start preparing to raise a family? It might be because the weather is

getting warmer. Or could the signal to the birds be that the days are getting longer? There are certain facts which seem to favour this idea. Birds which spend the winter in Africa arrive back to breed in England just about the same time each spring. They arrive almost at the same date each year, and yet the weather is very different every year; sometimes it is mild in March, sometimes very cold. But although the weather varies, the length of daylight goes on increasing quite regularly day by day, and this change in the length of days is exactly the same each year. Perhaps, then, it is the length of day that decides when some birds arrive back from Africa to breed.

Starting from this idea, a zoologist in Canada has lately made experiments with birds. In November he prepared two big aviaries out of doors. Into each of these cages he put about one hundred finches, birds something like our chaffinches. One of the two cages had electric lamps in it, and these lamps were lit at sunset for five minutes longer each evening. In this way the time during which there was light in one of the cages increased each evening just as it would do in spring, although really it was only November. By the beginning of January the birds in this cage were ready to breed; but the birds in the other cage, which had no electric lights in it, were not ready to breed until March, just like wild birds. And the birds with electric light were singing loudly in December, but the others were silent all the winter. Incidentally, this reminds one of an old custom in Japan, where the cages of pet birds are lit up for three or four hours after sunset each day in winter to make the birds sing.

In the Canadian experiments it must have been the extra light each evening that made one lot of birds ready to breed in mid-winter, for the lighting was the only difference between the two cages. These experiments suggest, then, that it is the additional light on each successive day in spring, not the extra warmth,

which causes birds to nest. Indeed in these experiments both cages were very cold indeed, for winter is extremely severe in Canada. In December there were sometimes as much as 80 degrees of frost in the cages, but in spite of this the birds in the cage lit in the evenings got ready to breed. But still, temperature also has an influence, for in England a cold spring means later nesting.

It has been found that extra light on winter evenings has the same effect on ducks, canaries, sparrows and starlings as on the Canadian finches. Pheasants, too, can be made to breed earlier with artificial light. And this applies not only to birds: ferrets normally breed from February to August, but extra light in autumn will make them breed in December. So it may well be that foxes and other wild mammals also get the signal to breed from changes in hours of daylight. Moles, however, which breed underground, must answer some different signal.

The hours of daylight, getting longer each day in spring, make birds breed, and ferrets, too, and perhaps foxes, wild rabbits and hares. But what about deer and sheep? These animals mate in the autumn, not in the spring. Sheep mate in the autumn and the lambs are born in winter. If the changing length of day gives these animals the signal to breed, it must be the shortening, not the lengthening, of the days. No scientific investigation has been made to settle this question with deer or sheep, but experiments have been done with a certain kind of fish. This is the brook-trout, a fish which spawns in autumn. When brook-trout were kept in a large aquarium which was artificially darkened at an earlier time each evening in the early summer, they spawned sooner than they would have done in nature. Of course, as in all scientific experiments, "controls" were also made; that is, other fish were kept in aquaria which were not darkened earlier each evening, so as to be sure that it was not some other unsuspected circumstance in aquarium life

which had induced premature breeding. From the experiments it was concluded that the diminishing length of each successive day really was a factor in causing brook-trout to breed.

It is clear, then, although this is not generally realized, that questions concerning animals such as "Why do birds breed in the spring?" can be answered in two different ways. One answer tells you what good it does to the animal—many animals breed in spring because it is the best season for their young to start life. The other answer tells you how it happens—many animals breed in spring because the days get longer. This second answer can go on telling you more and more, as scientists find out more facts; indeed they have already found out considerably more on this very subject. We know now that light causes a certain gland, the pituitary, to become active in the birds, and this gland discharges a chemical substance, or hormone, into the blood, which in turn acts on the brain and makes the birds sing and build a nest, and so on. This is the second kind of answer. We shall never know the whole of this answer, but we shall go on finding out more and more of it.

CHAPTER VIII

ANIMALS THAT FIND THEIR WAY HOME

CASES are frequently reported of animals finding their way home over great distances. Cats are said to return to their old home many miles away from the place they have been taken to. Homing pigeons regularly get back after they have been set free even hundreds of miles away from their loft. The most surprising cases of all are the migrations of birds. In the late summer swallows leave Britain and other European countries

and fly off to South Africa for the winter. A photograph on Plate IX shows swallows collected together in preparation for their long flight south. These birds come back again next spring, sometimes to nest in the same building. How do they do it?

Bees go out from their hive, exploring the country for a mile or two around in search of honey. Biologists have found out quite a lot about how bees find their way home again to the hive. Here is one of many experiments that have been made. A number of bees were put in a box and taken away from their hive. They were set free at a certain place which was about a couple of miles from the hive. When the box was opened, the bees flew up in the air, and then some of them—but not all—after circling round in the air once or twice, flew away and got home to the hive. It was known that the actual bees which had been in the box got home, because all of those in the box had been marked with spots of coloured paint. But some of the bees did not fly home; some of them returned to the box in which they had been carried, which was still lying on the ground at the place of liberation. It is thought that those bees which got home to their hive found their way back because they knew the country; they used their eyesight and their knowledge of the landmarks to find their way. The other bees did not know the country; they only recognized the short way back to the box.

What is the evidence for this interpretation? Here is another experiment which helps to give the explanation. A certain hive stood on the edge of a lake. Twenty bees were taken from this hive and marked with paint spots. Then they were put into a box and taken several miles inland, where they were set free. Seventeen of these twenty bees returned to the hive. Another day, these same seventeen bees were put into a box and taken in a boat several miles out on the lake. When they were freed over the lake they flew around in all directions but none of them got home. They

could not find their way home this time, and the reason seems to be that out on the lake there were no landmarks to guide them. These experiments and numerous others have shown that sight, not smell or another sense, guides the bees. They learn to know the neighbourhood by sight. Those bees in the first experiment which flew back the short distance to the box must have been young bees that did not yet know the country.

Eels, once in their lifetime, travel thousands of miles to their spawning place. They die there and their young travel thousands of miles back again to the land from which the parents came. This is what actually takes place. When eels are about ten years old, they swim down rivers to the sea. Eels in most countries of Europe do this. When they arrive at the sea, they swim out into the Atlantic Ocean. Even the eels from Egypt swim right through the Mediterranean Sea into the Atlantic. Once in the Atlantic, they all swim on and on to deep water near the West Indies. Having arrived there, the eels lay their eggs, and then they die. Young eels develop from the eggs, and they start the long journey back to Europe, swimming at the surface of the sea. They take three whole years to reach Europe. When the young eels arrive at the mouths of European rivers they are just over two inches long and are called elvers; they swim up the rivers in masses. I have seen swarms of these little elvers at Alexandria in Egypt wriggling up a weir to reach a lake; there were thousands of them struggling up the wet almost vertical wall. Some of the eels which ascend our rivers continue their journey overland during heavy rains, so reaching ponds. In rivers and ponds the eels slowly grow until they are about ten years old and then they are ready for their immense journey to the West Indies.

What guides the eels on their travels? The young ones, swimming at the surface of the sea, are brought from the West Indies to the coast of Europe by the

prevailing currents, principally the Gulf Stream. But what guides the fully grown eels travelling from the mouths of their European rivers right out into the Atlantic and then across the ocean to their spawning ground? What guides Egyptian eels on the long westward journey to Gibraltar, through the Straits and far out across the depths of the Atlantic? It is not currents this time, and we do not know the answer. We have not even got a reasonable theory.

Salmon, too, make long journeys to spawn, but they move in the opposite direction to eels. They swim from the sea up into rivers to breed. The eggs are laid on the river bed, near the head waters. The young salmon remain in the river usually for two years and then they swim down to the sea. There they spend two or more years, feeding greedily and growing rapidly. When nearly ready to breed they enter the river again and swim up to its head waters, jumping considerable obstacles where necessary. The age of a salmon and the lengths of time it has spent in the sea and in the river are known from natural markings on the scales.

It is very remarkable that salmon usually return from the sea to the same river in which they started life, not to another river, although they may have swum far from the river's mouth out into the sea and so could just as easily enter another river. That the great majority of salmon do return to the river of their youth has been proved by marking the young fish so that they could be recognized again. The marking was done by cutting a small piece off a fin. But we have no idea as yet of what it is that supplies the fish with clues for finding the right river again—what landmarks they can recognize, or what temperature and current changes influence them.

Whatever the clues may be, it is a most interesting further question as to whether the return of the salmon to their native river is due to an inherited instinct, or whether it results from the individual experience of the young fish, acquired while they swam down into the

sea. This question has been tested and answered by taking salmon eggs from the river in which they were laid and putting them into another river in which they subsequently hatched. The experiments were made in California. The young salmon grew in the river into which the eggs had been transplanted, and then a large number of the young fishes were marked before they swam down to the sea. The experiments showed that those marked salmon later on came back from the sea to spawn in the river in which they had spent their youth; they did not enter the river in which the eggs had been laid from which they developed. So there is no inherited habit to return to the ancestral home; the fishes learn the way during their individual lives.

Tales of cats and dogs finding their way home have often been told. Many of these stories may not be true, but I have no doubt that there is truth in some of them. Here is one such case. A man went 25 miles from home by train to shoot. When his day's shooting was over, he returned by train, but, by a mistake, his five dogs were left behind. Within a week four of these five dogs found their way home on foot, over snow-clad country. How did they do it? Of course, dogs know the neighbourhood around their home, chiefly by smell. But these dogs can hardly have known the country 25 miles away from their home, either by smell or by sight. We have no explanation of how the dogs found their way back.

Here is a scientific experiment on the homing of birds, the facts of which are quite certain. A few years ago seven swallows were caught near their nests at Bremen in Germany. They were marked with a red dye on some of their white feathers, so that they could easily be seen. Then they were taken by aeroplane to Croydon, near London; this is a distance of 400 miles. The seven swallows were set free at Croydon. Five of them flew back to their nests at Bremen. How did the birds find their way on that long journey, which they had never made before? That is the great puzzle.

It is no good saying that the swallows, or the dogs, have a "sense of direction," or an "instinct to go home." These are just words and explain nothing. We want to know precisely what senses the animals use to find their way, how they know in which direction to go until they can pick up familiar landmarks. Unfortunately practically no scientific experiments have as yet been made on this question.

Perhaps migrating birds are the greatest mystery of all. Swallows leave England in August and September, and they fly to Africa, where they stay during our winter. The swallows return to England in the spring, to nest. There are other birds too that leave England in the late summer for the south, for instance cuckoos and nightingales. A lot has been found out about the journeys of migrating birds by marking the birds with aluminium rings put on one leg. An address and a number is written on the ring. A photograph on Plate IX shows such a ring being fixed on to the leg of a bird. Swallows from England go as far as South Africa; and as many as fourteen birds, marked with rings in England, have been caught again in South Africa. From England to South Africa is a journey of 6,000 miles. And the birds not only return from Africa to England next spring, but often they come back to nest in the very same house where they nested the year before.

How do the birds find their way on these enormously long journeys? The young birds are not taught the road by their parents, because often the parents fly off first. Cuckoos, for instance, leave England a little time before their young begin to fly. We have no idea how the birds find their way, particularly as many of them fly by night, when landmarks could hardly be seen. And other birds migrate over the sea, where there are no landmarks at all. A certain kind of plover, for instance, nests in Canada. At the end of the summer these plover migrate from Canada to South America; they fly 2,500 miles, non-stop, over

the ocean. Not only is this very long flight an extraordinary feat of endurance, but there are no landmarks on the ocean to guide the birds.

It has been suggested that birds can sense the magnetic lines of force stretching from the north to south magnetic poles of the earth and so direct themselves. But all experiments hitherto made to see whether magnetism has any effect whatsoever on animals have given negative results. Still, where there is such a biological mystery as migration, even improbable experiments are worth trying, and research was being done in Poland, before the invasion of that country, on the possible influence of magnetism on path finding. Magnets were attached to birds' heads to see whether their direction-sense was confused thereby. These unfinished experiments had, of course, to be stopped.

CHAPTER IX

RACING PIGEONS

PIGEONS have been used by people for carrying messages for an immensely long time. They were used by the ancient Greeks some centuries before Christ. The Greeks sent the names of the winners in the Olympic Games to their home towns by pigeon, the message being attached to the pigeon's leg. Seventy years ago, during the siege of Paris, the French sent messages by pigeon post out of the besieged city. Then the Germans tried using trained hawks to kill the French pigeons. In the last war homing pigeons were used to send back messages from front-line trenches, when telephones had been destroyed. In this war pigeons are being used by the R.A.F. over the sea. If a plane is in difficulties, or is shot down and the airmen have time to get into their rubber boat, they send

off a pigeon with a message giving their position attached to its leg, and the pigeon flies back to its loft in England. When it arrives, the bird, by alighting on its perch, automatically rings an electric bell and so no time is lost. Use is now being made of pigeons to give the position of ships when wireless would betray them to the enemy. This has unfortunately meant the persecution of one of our rarer birds of prey, the peregrine falcon. In peace time these birds, which are never very numerous, are protected by law: it is an offence to shoot them. Now they are shot because they kill homing pigeons.

In peace time, pigeon racing is a sport. This is how a race is conducted. Hundreds of birds are sent by train, in baskets, to the starting point, which may be several hundred miles away from the homes of the pigeons. The baskets are sometimes to be seen on railway platforms with the birds inside them. Each pigeon has a numbered race-ring on one of its legs. At the start of the race, in the morning, the baskets are opened, and it is a remarkable sight to see the immense quantities of birds rise up together in the air and make off in the direction of home. Plate X shows a start, just after the birds have been released from baskets by railway porters.

The winning bird, and the other best fliers, get home on the same day. If it is a long race they are set free at the start at dawn and they get in by nightfall. Some races are very long indeed; they start in France or even Spain and end in the North of England. The distance may be over 700 miles, yet the winner will do this in a day. Its speed is very great. A pigeon has flown a race of 600 miles at an estimated speed of at least 57 miles an hour. Really its speed was certainly much more than this, for the bird does not fly in a straight line. When the first bird arrives home at each loft, its numbered race-ring is removed from the leg and placed in what is called a " racing clock " which stamps the exact time, with the number of the bird, on a dial.

Of course, all the birds that start do not get home. Some get home late, days after the race has started; others are lost. And the longer the race, the greater the number lost. A third of the starters may be lost in the longest races. There are several reasons for losses. Some birds undoubtedly get lost because they are not good enough at their job—they get tired, or they can't find the way. Many losses are caused by fog and mist; for pigeons cannot find their way in a fog, even if they are only 2 or 3 miles from home. One cause of pigeons getting home late is that they like flying in company; many racing pigeons cannot resist the temptation of joining a flock of pigeons flying to another area, if they meet one.

This is how the birds are trained to race. Training starts when the pigeons are 2 or 3 months old. They are first of all let loose a mile from home, then 2 miles, then 4 miles, and so on. The young birds have an instinct, or desire, to return home, but for racing each bird has to learn, by gradual stages, how to get home quickly. After the young birds have been trained to return from, say, 4 miles, they are taken, for example, 7 miles, then 12, then 20, 30, 60 and 100 miles away: the difference between the stages gets longer and longer. The birds have now finished their first year's training, and they are flown in "young bird races" of 100 or 150 miles. The training and the racing are usually both done in a certain definite direction. A bird trained over a course straight to the south of its home is raced from the south.

Next year those birds which are still alive, and have not been lost, and particularly those which have done well in races, are trained over the same course again, to refresh their memories, but this time there are not so many stages in the training. After this they are taken in one single step much further afield. For instance, birds trained to race from Eastbourne to Norwich, which is 135 miles, are then taken across the Channel and raced from a point in France about 150 miles

further afield than Eastbourne. Those birds which get home from this place are sent, for another race, 100 miles further away still. And finally, at a later date, they are sent yet another 150 miles afield, so that the length of the last race is about 500 miles. The start for this race is near Bordeaux.

Now comes the most interesting question as to how the birds find their way. It is possible that the young pigeons learn to know by sight the landmarks in the country they have been trained in. They may learn the country, and use their eyes to get home. It is probable that they do use their eyes, for they are confused by mist or fog. And homing pigeons do not fly at night; they are helpless after dark and cannot see their way.

So far so good, but now comes the real difficulty. It is this: after birds have been trained stage by stage to fly home from 100 miles out, they can then safely be raced from 100 miles further afield, all at one jump. They do not have to learn this second 100 miles step by step. How, then, do they find their way over it? There are several possible explanations.

When pigeons are set free in unknown country, say 100 miles from the nearest place they know, but always farther out in the same direction, this is what they do. First they may fly up and circle round in the air, and then fly away. In which direction do they go? It might be that they fly in all directions, and only those get home which by chance happen to go the right way until they pick up landmarks they know by sight. But too many birds get home for this to be the correct explanation. And actually the birds do not fly off in all directions, for lost or tired-out birds are not found afterwards in the direction away from home, but towards home. And there is a stronger reason than this for saying that the birds, when set free in country unknown to them, fly off in the right direction towards home. Sometimes the birds, freed to begin a race in unknown country, do not circle in the air at all before

flying off. Instead, they can be seen to fly away straight towards home as soon as they are let out of the baskets. Young birds, too, when they are freed at a new point in their training often make for home in a bee-line at a low height, without any circling. They do not hesitate.

Something directs the birds towards home. What can it be? Now, pigeons are usually trained to return home from the same direction in which, later on, they are raced. For instance, they are trained to return from south to north and they are afterwards raced in this direction. It might be, then, that during their training birds not only learn to recognize landmarks, but that they also learn that their home lies in a certain direction on the compass, for example, to the north. Then, when set free 100 miles farther south than they have been trained, they fly back to the north. Still, how would the pigeons know the direction? How would they know which is north?

Magnetism has been suggested. But the birds can hardly have a magnetic compass in their head. Nothing like a compass has even been discovered in a bird's head. Perhaps it is the sun which gives the direction to the pigeons, for they are lost at night. But here we run into a further difficulty, for if the sun tells the birds which is north, they must be able to know the time of day. Because, of course, as you go north in the northern hemisphere the sky is brightest in the morning on your right hand, in the afternoon on your left. So if the birds use the sun to give their direction, they must know the changing time of day. This is not impossible. It has been proved that certain animals can estimate time-intervals, as will be explained in the next chapter. It is conceivable that pigeons would know unconsciously the angle between, say, the direction of north and of the sun, or brightest part of the sky, at various hours counted from dawn. But this is asking a lot—and there are other difficulties.

As we said, birds are usually trained in the direction

in which they will be raced. But some pigeon fanciers, who are very successful in winning races, will take a bird which has been trained and raced, for instance, from the south to Birmingham, and then put it in for races from the north. Such birds have sometimes done very well in races from what you might call the wrong direction. Of course, these birds might have been guided home by flying most of the way with the flock of other racers. But this will not explain everything. Here is one case out of many. The owner of a champion bird in Birmingham, which had won prizes in the longest race, all the way from San Sebastian in Spain, decided to race this bird in the other direction, from the Shetland Islands to Birmingham. For practice he first of all freed his bird 100 miles to the north of Birmingham. The bird got home in spite of the fact that all its training and racing had been from the south. Then this bird won the race from the Shetlands. In this case the suggested explanation that the bird had learnt the direction of home on the compass during its training would not fit the facts.

Moreover pigeons can find their way home from long distances without any training in any direction. They are not able to do it as well as trained birds, and more of them are lost, but some do get home. Experiments have been made which have proved this. In one experiment seven completely untrained young birds were set free in Kent, 100 miles away from their loft in Norwich. One was home the same day, another next morning, the rest did not get home. In another experiment, from a lesser distance, all the birds got home. In this case seven untrained birds were set free 58 miles from their loft. Three of these birds arrived home together on the same day. Their speed worked out at only 18 miles an hour, assuming that they had come straight. This is so slow for racing pigeons that almost surely they did not come straight. All the other four birds got home too, but not on the same day, the last coming in 19 days later, so these birds may have

wandered about until they picked up familiar landmarks near home.

It is clear, then, that the training of racing pigeons over a certain course teaches them to find their way home better than they would otherwise be able to do, for many fewer trained birds are lost than untrained birds. The trained birds learn to find their way home very well and very quickly in a certain direction on the compass, although we have as yet no idea at all what is their compass. But this is not the whole story, for untrained pigeons can also find their way home, just as the Bremen swallows did in the experiment recounted in the last chapter. We cannot explain this at all. Indeed the way that animals find their way home is one of the greatest mysteries in the whole of biology; scientists have not got a theory or even a working hypothesis to explain the facts. But I have no doubt in my mind that future scientific experiments will give us the explanation.

CHAPTER X

CAN ANIMALS COUNT?

THE most famous case of an animal said to be capable of counting was that of a horse in Germany called Clever Hans. This was at the beginning of the present century. Its owner believed that animals can think and reason as we can and that this faculty can be brought out by training the animals. He trained Clever Hans to give the answers to problems of arithmetic; the horse gave the correct answer by tapping the right number of times with its forefoot. Clever Hans was taught to tap units with one forefoot and tens with the other. The animal gave the correct answers not only

to additions but to other processes of arithmetic, including converting fractions to decimals. It gave the right answers too when the questions were not spoken but shown to it written on a card.

This case was so much talked about in the newspapers that a committee of scientists was formed to investigate the astonishing powers of the horse. The committee after a careful investigation found that the owner and trainer of Clever Hans was an honest man, that he had not purposely trained his horse to stop tapping, and so to give a correct answer, by giving it a slight cue as is done with performing circus animals. The absence of any such trickery was proved by the fact that members of the committee themselves got the right answers from Hans even when the owner was not present.

It looked as if the horse really could think and count. But soon after this another scientist discovered what really was the truth of the matter. He found that if the horse was asked questions to which none of the people present knew the answers, then the animal never gave a correct answer. It could not even answer the simplest question. The questions were asked by showing the horse a card which the questioner himself had not read. This biologist soon discovered that what really occurred was this: the horse responded to almost imperceptible movements of head or body made by a questioner who knew the answer. These movements were quite unconscious, and the questioner did not know that he made them. But the questioner, of course, knew the number of taps that the horse should make. He counted the taps to himself, and when the horse arrived at the right number, the questioner's tension would be relieved by a very slight unconscious head or body movement. It was to this movement that the horse responded by stopping the tapping of its foot. Questioners who did not know the answer made no such movements, so the horse was confused. The horse had really taught itself to answer these very small

movements during its training; it was always induced to try its best by rewards of corn or sugar.

This case has become very important in the technique of investigations on the senses of animals. What is now known as the "Clever Hans error" is scrupulously avoided in such studies by having the experimenter hidden from the animal. He watches the animal through a peephole, and presses hidden buttons to give the signals to it.

But can animals ever really count? Consider children first. Long before a child can count, or know what numbers mean, it notices certain differences in the quantities of things. A young child can tell that a group of sixteen counters contains more than a group of fourteen; the child knows that one of the piles of counters is bigger than the other. Many animals can distinguish quantities as the child can. For instance, experiments have shown that a pigeon chooses a pile made up of five grains of corn in preference to a pile of four grains; it prefers six to five, but it cannot distinguish between seven and six.

These are differences perceived between numbers of objects presented simultaneously to the child or the bird. There is, however, a more difficult case of simple counting, namely to know the difference between numbers of objects at successive times. A child, for example, misses one toy out of a lot which were all alike; it misses one brick out of several, after one has been removed. So, too, a bird may abandon its nest if two of its four eggs are taken away when it is absent for a short time from the nest, but it will not notice that only one of the four has been stolen.

Still, this is not all that animals can do. Some seem to be able really to count in an elementary way. For instance, hens have been trained to take every second grain of corn out of a row of grains. The training was done by sticking every second grain of a row to the ground. The hens soon learnt only to peck at the loose grains, and afterwards they only pecked at every

second grain when all were loose. In the same way they were taught to peck at every third grain. Likewise a child of two years old has been taught to pick every second chocolate from a row of the sweets.

Long ago it was found at the Zoo that a chimpanzee can count. The experiments were done with a famous ape called Sally. With the help of the keepers she was taught to pick up one, two or three straws when asked for them, and hand over the right number of straws. Later she learnt to pick up four and five straws when asked, but that was as far as she could count; above five she made mistakes. Sally even seemed to have some idea of multiplication, for she often doubled up a long straw so that the two ends met, and counted this as two. There are primitive races of man who can hardly count better than this.

Besides being able to count, human beings have another less precise faculty, that of being able to estimate the lapse of time with a certain variable degree of exactitude. This can apparently be done when sleeping as well as awake, for many of us will guarantee to wake up at a certain definite hour if this is necessary. And in the daytime we can estimate the passage of hours or of minutes with a greater or lesser error. Have animals any similar capacity? Some of them have: bees are able to estimate time intervals, and they can do it better than most of us.

There are flowers which open and close at definite times of day, and when on a certain day in spring or summer a new kind of flower comes into bloom, bees quickly learn by experience at what time to go for the nectar on the following days. This time-sense of the bees has been studied by experiments similar to those used to test the colour-sense. A feeding table was placed out of doors. A sugary liquid was put on the table for a short time at a certain hour each day. While the bees were sucking their fill they were easily marked with paint spots so that they could be recognized again. Unmarked bees which came to the table, having been

informed of the booty by the dance of the discoverer on her return to the hive, were killed. In this way a group of marked bees was kept under close observation for days. It was found that each day the greatest number of bees visiting the table came just at the feeding hour. Very few came at other times. Then one day no food was offered. The bees came at their usual mealtime, and in spite of the fact that no food was offered on the succeeding days they continued to come every day for a week at the right time, although they now came in vain. They had learnt the mealtime and they remembered it.

It was found possible to train the bees to come punctually to as many as four mealtimes per day. How do the bees know the times to come? What is their clock? This is the really interesting question. The bees' clock is not hunger, for they were never hungry. Bees eat food in their hive at all hours of day; the experimental bees did not depend for food on the sweet liquid on the feeding table. They collected it to store it in the hive as honey. Hunger is not the bees' clock, nor is it the position of the sun or the changes in daylight from morning to evening, for the same experiments were successfully repeated indoors, in a large room with constant electric lighting throughout day and night. The bees' clock is not hourly changes in temperature or dampness, for these were kept quite steady in the experimental room. It was thought that daily change in intensity of cosmic rays from the sky might be the bees' timepiece, so all the experiments were repeated at the bottom of a mine where cosmic rays cannot penetrate. But the bees learnt the mealtimes just as well down there.

These experiments make it probable that no changes in the outside world tell the time of day to the bees. If this is so, it follows that they must estimate the time interval between meals by means of some inner clock. This clock seems actually to be the rate of chemical changes in the living cells of the bee's body. If such is

eally the case, changing the rate of bodily chemical eactions should upset the bees' time-sense. And so it oes. A dose of thyroid extract made them come early or meals, quinine made them come late. The former s known to hurry up, the latter to slow down chemical hanges in the body.

After these definite conclusions from the experiments with bees I am going to pass on to less secure ground, to the question of the time-sense of human beings. Most of us can make a reasonably good guess at how many hours have passed, or how many minutes have gone by, without consulting a clock. How do we do it? Is our internal clock the rate of chemical processes going on in our brain? If so, quickening the chemical processes should hasten the time-sense. Now usually, of course, our body temperature is very steady, but during fever it goes up. A rise in temperature means that all chemical processes go on at quicker rates. Starting from this idea, a scientist tested the theory that the rate of chemical reactions in the body is our timing mechanism on his wife when she had the 'flu. Without telling her what he was aiming at, he asked her several times during two days of fever to count 60 at the rate she estimated as one per second. On each occasion she took less than one minute to complete the 60 counts, and the higher her temperature, the sooner she completed the total.

If established by more rigorous experiments, this would bear out the theory. Moreover, it would account for time, judged by the clock seeming to be so slow during fever, as most of us have experienced. For with quicker chemical processes in the brain, due to the high temperature of fever, more mental time would pass per minute or hour of real time. This may be the reason, too, why hours and days are said to pass more slowly in youth, than later in life, for bodily chemistry is quicker in youth. It is as if two trains ran side by side in the same direction, one representing real astronomical time, the other mental time. At

first, in youth, the trains are running at equal speeds. Then, as age advances, one of the trains (mental time) slows down. The other train (real time) goes on at a uniform pace, but to passengers in the train which is slowing down it appears to accelerate.

CHAPTER XI

SOCIAL RANK

MALE animals are usually dominant over their females —but not always. Males are dominant to females among cocks and hens in the farmyard. Female baboons are always subjugated to males; a female behaves as if paralysed while rival males struggle for her. In the case of all monkeys and apes it is the male that decides when and how often mating shall take place. But in the case of various other mammals—cats or rabbits for example—it is the female which decides whether mating shall take place or not.

The male monkey is dominant over the female in mating and for all the amenities of life. He is completely selfish. If there is a limited amount of food for a baboon family, the father takes all. His wife, or wives, with their children, get none until he is satisfied. The female baboons themselves are secured by the dominant males just like material objects; the weaker males get none, and they are compelled to live sterile bachelor lives. Plate XII shows a baboon family, and on the cover of this book you see a downtrodden baboon wife grooming her bully of a husband.

The marital relations of seals resemble those of baboons. When seals come to the coast at the breeding season, the strongest bulls each collect a harem of cows around them on the beach, while the young and weaker males are banished to bachelordom. With

the baboons, curiously enough, a male who is an overlord of females, possessing one or more wives, is not necessarily dominant over other males for food. He may engage in an undignified scuffle with the subdued bachelors to secure some morsel to eat, and even if he is worsted he does not lose his females. If a bachelor tries to get one of the females, however, a fight results, and then the overlord is sometimes deposed.

Many male animals fight for the females. Baboons struggle for wives and seals fight to collect a harem. Stags grow fantastic antlers each year and use them in fighting for the possession of hinds. After the mating season in the autumn the antlers are shed. In spring they grow again, the bony core being formed by the outside layer of warm, living flesh called "velvet." In summer the velvet dies and falls off and the bony antlers are ready for the fight. The stags spar with one another, head to head, each feinting for an opening to jab the adversary in the ribs.

There are other animals in which the males strive for females mainly by terrifying one another, without really fighting. Baboons bare the teeth and erect their beautiful fur. The mandril has not got the baboon's cape of fur, but he has strange and weird colours on his face, possibly to terrify his rival. Was the human beard once for this same purpose? If not, what was its use? Surely not for the female to choose the most beautifully bearded male, for in none of our simian relations do females choose their mates.

Male animals are not always the leaders. Only during the breeding season are cock parakeets dominant to the hens; at other times of the year the males are henpecked. This is true also of wild ducks. In the case of deer the social system is matriarchal, not patriarchal; the stag is never the leader. For most of the year the two sexes of deer live apart; there are groups of stags and groups of hinds. In a hind group one individual is the leader. Usually she has a calf with her. She is a regular breeder and retains her leader-

ship probably until her death. She is constantly on the alert—smelling, listening, hearing, for the herd's welfare. The stag companies are much looser, and there is no apparent leader, though one stag may bully the rest. In the mating season in autumn the stags fight and each winner collects a harem. But though a stag herds together a group of hinds, with all of which he mates, and he keeps other stags at a distance from his harem, yet he is not the leader of the group. He does not watch for danger. The leading hind does this, and if danger threatens she leads the retreat, while the stag makes his escape alone. The stag is an egoist.

Quite apart from differences of sex, many animals that live together establish a social order among themselves. There are bullies and bullied. This is the case with monkeys. When food is put into a cage at the Zoo, the dominant individuals secure it all, while the other monkeys do not even try to get any. If, by good luck, a weaker monkey does manage to secure some of the food, but is noticed, he must give it up. Many monkeys have cheek pouches into which they stow away food to be consumed later. Even if the weaker monkey has managed to cram his stolen morsel into his cheek, it is fetched out by the bully, who puts his hand right into the cheek pouch.

A number of hens living together very soon establish a definite social order. This is decided by the first encounters between pairs of the hens. Either they fight and one bird wins, or else one dominates the other without having to fight, the second bird submitting passively. Thus there is either a physical victory or a psychological one. In either case the matter is settled, and thenceforth the victor pecks at the vanquished whenever she chances to meet her, but the vanquished does not peck back. The victor frequently exercises this right which she has acquired of pecking without being pecked in return. Revolts rarely occur, and successful revolts, resulting in a change of social status, are still more rare.

In any group of hens such a social order is established, in which each bird is pecked by those above her and pecks those below. The lowest bird is pecked at by all and retaliates on none. Birds that are high in the social order usually peck their more immediate social inferiors more often than they peck those lower in social rank. This is perhaps because the lower birds avoid their superiors when these come too near. It is interesting to find that birds, like football teams, win more often on their home ground. A bird which will win many first encounters when she is at home and her opponents are strangers, will usually lose against almost any opponent on the latter's ground.

The degree of despotic behaviour of a hen depends upon her rank in the social order. A bird low in social status, which has only one or a few others beneath her in a big flock, handles these few more roughly than a bird which rules over many others. Something like this has been observed in monkeys too; in a group of three, the second in order of prestige was not so badly treated by the first as the third monkey was by the second. If a hen which is very low in social rank, and therefore a harsh despot, is raised to a higher rank in another flock, her despotism soon becomes much milder. If a despot is left to live alone with an inferior, a friendly relationship may come to be established between them. Human analogies are not far to seek.

High social rank among birds seems to mean greater freedom of action, easier access to food and a less strained style of living. But the top bird in a penned flock is not necessarily the leader on a foraging expedition in the open. If the birds are released in a field, the dominant bird, or those near the top of the social scale, may or may not be at the head of the foraging flock.

The most interesting recent scientific study of social rank in birds deals with its cause. The question is this: what is there inside the body of an individual which decides whether he shall be a top dog or be

subservient? In the first place, it is a fact that a male animal usually stands above a female in social order; the male is more aggressive. Now, it is well known that female individuals have some male qualities. In certain instances the male characteristics of females are quite exaggerated; we can all think of cases of this among human beings. The visible features of a male or a female bird, that is the feathering and the shape and size of comb, depend on chemical substances called hormones which are formed by the male or female organs and which circulate in the bird's blood. But a bird of either sex, in addition to possessing the hormone proper to its own sex, also has a little of the hormone of the opposite sex in its blood.

A knowledge of these facts led to the theory that perhaps the quantity of male hormone present in the blood of a hen decides her degree of aggressiveness to her neighbours. The more male hormone she had, the more aggressive would she be. This theory has now been tested by experiment. Male hormone has been prepared in a chemically pure state. Small amounts of pure male hormone have been injected into hens with a hypodermic syringe, and this has given astonishing results. The effect has been an increased growth of comb and a falling off in the rate of egg laying. More than this, the injected hens started to crow, and sometimes they even began a courtship of other hens in the same way that cocks court. One wing was dropped and fluttered quickly against the bird's side while she sidled up to another hen, at the same time moving a foot up and down in an exaggerated manner.

What interests us particularly here is that such injections of male hormone into hens low in social rank soon improved their status in society. These hens came eventually to occupy the top position in each flock. This makes it clear that the amount of male hormone in a female is at least one important factor in determining her aggressiveness.

CHAPTER XII

INSTINCT

INSTINCT is a word that is often misused. It is a word which has not at all the same meaning when an ordinary man employs it, speaking about himself, as it has when a biologist uses it. A person will often say: "I did this or that instinctively," meaning that he did the right thing without thinking out how to do it. As I shall explain in the next and last chapter, in most cases the person's action was probably not at all an instinctive one in the scientific sense of the word. First of all, then, what does the biologist mean by instinct?

We can best begin to answer this question by taking some striking examples of instincts. Maternal instincts are very familiar; the photograph on Plate XIV shows a mother giraffe about to feed her young. Kangaroo mothers carry their offspring about in a pouch, and bats fly with the young hanging on to them. Plate XV shows how a mother bear carries her cub by its head, a method that seems very strange to us. Self-defence is an instinct, but defence of their young by parent mammals and birds is an even stronger instinct. An animal will defend its young at its personal peril. Whereas it would have fled had it been alone, with its offspring it stops to fight. More complex instincts than those of defence are nest-building by birds and hive-building by wild bees.

What is the most striking feature of instincts? It is that they are inborn; they do not have to be learnt. Birds of a certain kind, swallows, or thrushes, or storks (see Plate XI), build their own particular sort of nest in the spring without their parents or acquaintances showing them how to do it. Spiders of each different species construct their particular type of web without having had a lesson in web-making.

That there is no learning concerned in an instinct is especially clear when the instinct is used only once

in the lifetime of an animal. Caterpillars, for instance, know perfectly how to make their particular kind of cocoon, although they do it once only in their lives. Eels, when they reach the age of ten or more years, migrate down rivers to the sea, and then go on across the Atlantic Ocean to the West Indies, where they spawn and then die. All eels from European fresh waters make this journey before they breed, but there is no one to tell them when to start or to show them the way.

Instincts are inherited; that is, they are inborn. They do not improve with practice. A spider makes as perfect a web the first time in its life as it does after it has made many webs. Another proof that instincts are inborn, is that individual animals which have been brought up in isolation nevertheless carry out their instinctive actions quite perfectly. A young moorhen was once raised alone. When the young bird was first put to swim in a stream, it suddenly became frightened at a puppy. The moorhen was seen immediately to dive, for the first time in its life, although it had never seen its parents dive. Having dived, it swam some distance under water out of danger. A yellowhammer, reared apart from its parents from the fourth day after hatching, later on built a typical yellowhammer's nest of grass, moss and hair, in the normal position low down near the ground.

Instincts appear at certain definite times in the life of an animal. Often hormones are responsible for the appearance of an instinct. Nest-building, for example, is undertaken by birds when chemical hormones from the sexual organs circulate in the bird's blood, so reaching the brain and giving the signal for a nest to be begun. Instincts of one sex have been artificially produced in the opposite sex by operations, proving that they depend upon hormones. In one such experiment the testes, or male organs, of rats were removed and ovaries from females were grafted in their place. The result was that the operated male rats developed female

instincts; they even produced milk and suckled young. This was due to the female hormone from the grafted ovary, which circulated in the blood of the male rat.

In honey bees the workers in the hive have a whole series of instincts, one after another in a definite and unvarying order, as they live their short lives. Successive chemical changes in the bee's body probably start off each instinct. A bee commences its life as an egg laid by the queen in a wax cell of the comb in the hive. From the egg comes a grub, which after a time turns into a pupa. Later on a bee emerges from the pupa skin. The vast majority of the bees are workers.

As soon as a worker bee has come out of her pupa skin she dries and cleans herself. After that, she cleans out the wax cell in the comb in which she spent her youth as grub and pupa. It is only after a cell has been cleaned out that the queen will lay another egg in it. At the end of three days the worker begins a different job, that of feeding grubs in their cells. She takes honey and pollen from the food stores, which are in other wax cells in the comb, and gives this food to the grubs. After a few days at this job the worker again changes her occupation. Next she sucks up nectar from the mouths of older workers who have flown out from the hive, collected the sweet liquid from flowers and brought it home. She sucks the nectar from these bees into her own mouth. Inside her body the nectar is changed into honey. Then she squirts the honey out into special cells in the comb in which it is stored. The worker also takes pollen, which has been brought home by older workers attached to their legs, and packs it into other storage cells.

After a day or two at this job, the worker acts for a short time as a dustman; she carries dirt outside the hive. After that again, the worker produces wax. The wax is a product or secretion of her body, and with it she builds new cells on the comb. But after this job is finished, the worker may still have one more duty to do in the hive. This is to be guardian at the

door; worker bees guard the door of the hive, and sting any bees not belonging to the same hive that try to get in. And they sting any other insects that attempt to enter the door. Lastly, on her twentieth day out of the pupa, the worker starts flying out of the hive to collect nectar and pollen from flowers and bring this food back to the hive.

Thus, instead of having a single occupation as a man or woman would have, a worker bee has many occupations in her life, one after the other. But every worker bee does all these different jobs in exactly the same order. All these different jobs are instincts; every worker bee does them in precisely the same way. She has not got to learn her work. The instincts follow one another in a definite regular order because each instinctive action, when it has been done, changes the nature of the bee, so that the insect must go on and do the next job. As the bee gets older, chemical changes occur inside its body the result of which is that the bee is forced to undertake its successive occupations.

Perhaps the most striking characteristic of instincts is their purposefulness. They seem perfectly fitted for the lives of the animals. Yet there are imperfect instincts. Baby elephants, for example, have been seen to suck at the trunk and the tail of their mother as well as at her teats! Ants encourage certain other insects to live in their nests; these insects produce sweet juices which the ants enjoy drinking. But in some cases the insects are a positive danger to the ants. There is a certain kind of beetle which ants rear to get its sweet liquid; they look after and feed the beetle's young, although the beetles destroy the ants' own brood. This is an instinct which may be said to have turned into a vice. The case of the cuckoo is similar. The birds in whose nest the cuckoo's egg is laid instinctively feed the cuckoo chick, although it throws their own young out of the nest. The picture on Plate XV shows how much bigger the cuckoo chick may be than its misguided foster-parent.

Instincts are automatic, in the sense that they are inherited types of behaviour which have not been learnt. The animal doing an instinctive action can have no idea of its purpose. I will take one particularly interesting case to make this clear. There are certain kinds of wasps known as digger wasps because instead of building a nest they make a hole in the ground for their eggs and young. Before laying her eggs a female of one of these wasps digs the hole and then goes off to look for a caterpillar. Having found one, she stings it. The sting paralyses but does not kill the caterpillar. The wasp drags her prey to the hole, puts it in, lays an egg on it, and then seals up the hole with mud. Later on, a wasp grub hatches out of the egg and eats the caterpillar. Our wasp had never seen another wasp do all this, and she would never see her offspring hatch and feed on the paralysed caterpillar. Her actions were all instinctive; she had not learnt them and could not possibly realize their purpose, as she would never see their result.

Instincts have the appearance of being automatic, and indeed in many instances they are machine-like and inflexible. For example, there is another kind of digger wasp, related to that already mentioned, which stings grasshoppers, not caterpillars, and buries them as food for her future offspring. The wasp drags the paralysed grasshopper by its feelers or antennæ to the prepared hole. If the antennæ of the grasshopper are cut off, the wasp cannot tow in its prey, although the latter has legs which might be seized. The wasp's instinct dictates that antennæ shall be used, and it cannot make use of legs.

Here is another instance of inflexibility of instinct in the same insect. Before dragging down the grasshopper into the hole, the wasp always leaves it at the entrance and goes in alone to see or feel that all is clear. If, while the wasp is down in the hole inspecting, the grasshopper is removed a short distance, then the wasp on emerging drags the grasshopper back to

the entrance and again goes down to inspect. She can be made to repeat this performance a number of times; unless the grasshopper is at the mouth of the hole when the wasp emerges, she will not take it in.

The automatic character of instincts is sometimes seen most strikingly when animals are living in unnatural surroundings. In nature squirrels collect nuts and bury them; a tame squirrel in a room has been seen to put nuts behind the leg of a chair and to go through all the motions of burying them and pressing down earth on them. Dogs, before lying down on a carpet, may turn round several times as if flattening grass to make a good bed. Young partridges, which are coloured very like their surroundings, squat quite still when their parent gives a warning call. Their colour and lack of motion then makes them invisible to enemies. But partridge chicks also squat on a bright carpet if their mother gives the signal, although their colour does not protect them at all on that background. There is a certain kind of caterpillar called processional because the larvæ have the instinct of moving in single file in search of food, touching one another head to tail. The experiment has been made of so directing the front caterpillar of such a procession that its head came to touch the tail of the last one, a closed ring being thus formed. For a whole week these caterpillars continued to walk round and round, one after the other.

We have now seen examples of more or less complex instincts possessed by insects and by birds. Some mammals, but not many, have such instincts; for instance, hoarding by the squirrel. The most complex cases in mammals are the architecture of the mole and the beaver. Other mammals have no very complicated instincts. The dog buries its bone, the cat eats grass when out of condition, but these animals cannot in any way rival the instinctive feats of the beaver. We ourselves have certain simple instincts, but no complex ones. We have instincts of self-preservation, maternal

care, acting in common with a crowd, wishing to be a leader, and so on, but that is about all.

Sometimes actions of animals thought to be instincts have proved on investigation not to be so. One of the most characteristic traits in the character of a cat is that it catches mice. It was once thought that cats have an instinct to catch mice, but this seems not always to be the case. For instance, in an experiment repeated a number of times, a kitten of five months old was put into a cage with a mouse. The kitten had never seen such an animal before. It played with the mouse for an hour, as it would with a ball, but did not injure it. Then a fully grown cat was brought in. The cat killed the mouse at once. After this, again, the kitten did not injure mice for some time. Only after a number of repetitions did the kitten imitate the cat and kill a mouse. In other experiments it was found that kittens played with mice which were quiet, but killed mice that were wild and ran away. In this way they acquired the habit of killing mice. Cats brought up with rats have been found to be friendly to them. Plate XIII shows such a friendship between a cat and a young rabbit.

I read lately in a sporting magazine that "The natural instinct of dogs is to be of service to man." To the biologist such a statement is nonsense. The biologist's view is that each kind of animal has evolved, and in the course of its evolution has acquired certain instincts useful to it. In the next and last chapter we shall see how it is that some kinds of animals, including ourselves, get on with few instincts, whereas the lives of others are very largely instinctive. In general we may say that the lives of insects are largely directed by instinct, in birds instinct is important, but in mammals it takes a less prominent place. The lives of mammals are less rigid; each individual modifies its behaviour as a result of personal experience and thus acquires personality.

CHAPTER XIII

INTELLIGENCE

INTELLIGENCE, like Instinct, is a word which is commonly used with more than one meaning. The biologist hardly makes use of the word Intelligence at all, because of its ambiguity. I shall try to make clear what is the difference between the use of this word by different people, in particular the wide difference in its use by pet-lovers and by schoolmasters.

In the preceding chapter we saw how different animals are variously endowed with instincts. Insects know by inborn instinct how to do most things necessary in their lives. We, on the other hand, inherit very little of such knowledge; we have to learn to do almost everything. Between these extremes of the insects and ourselves there are all intermediate grades. Dogs have some inborn instincts, but they must learn many things which they have to do in their lives, and a dog is called intelligent or the reverse by its owner in proportion to its aptitude for learning. Among the most intelligent of dogs are sheep-dogs. Elephants are intelligent animals in that they readily learn the tasks that men set them to do; Plate XVI shows an elephant in Burma making a pile of logs.

All animals must learn to do some things in their lives. Even those animals whose existence is most completely ruled by instinct learn some of their activities. In the last chapter I described the long series of successive instincts in the life of the worker bee in the hive. But in the last stage of the worker's life, when she forages abroad for nectar and pollen, she learns a lot. As explained in earlier chapters, the bee learns to recognize the landmarks in the countryside and so is able to get home. She learns which flowers are offering most booty and she communicates this knowledge to her hive mates. In these matters her life is not ruled solely by inflexible instinct.

The process of learning is not always the same. There are various ways of learning, various steps in complexity of the process. The simplest kind of learning may perhaps best be described as muscular learning. Babies learn to walk, and so do puppies. They gradually co-ordinate and perfect the action of their leg muscles. Some birds fly clumsily when they first come out of the nest, but they quickly learn to fly perfectly. Insects, on the other hand, need no such practice; butterflies, bees or flies all fly perfectly the first time. When we try to improve our performance at a sport, or learn to ride a bicycle, we are engaged in muscular learning. Few would say that intelligence enters into this process.

Some learning is due to an instinct for imitation, especially the imitation by young animals of their parents or of their more enterprising brothers. Chicks begin to peck when they see their mother do so. The first pecking can even be started by tapping a pencil on the ground. Such imitation must be as automatic as yawning when your neighbour yawns; it could certainly not be called intelligent. Animals which catch prey, such as lions, train their young. They bring home wounded animals on which the cubs try their claws and teeth. And lion cubs, when they get big enough, are taken by their parents on hunting trips. Then they learn by imitation and practice. Foxes do this, too, with their cubs; they take them out and so teach them how to hunt.

Young animals may learn in this way by imitation, but fully-grown animals seldom imitate others, except, perhaps, in the very simplest cases such as sheep all going in the direction in which one of them moves. Scientific experiments have shown that when dogs are given a simple problem to solve, such as finding how to open a latch on a door, they are never able to imitate another dog which has already learnt how to do it. Monkeys are supposed to imitate human beings; the verb "to ape" and the French verb *singer* imply this.

But such is not the case. Merely because the actions of monkeys are like our own, our anatomical structure being so much alike, have they been assumed to imitate us. A number of monkeys were once shown that a banana could be extracted from a wide-mouthed bottle by turning the bottle upside down. Only one out of many copied the action and so got the desired fruit.

The most common way in which animals learn is by making mistakes and remembering to avoid them in future. Puppies learn to be clean in the house, so avoiding punishment. Stage dogs learn to do all sorts of clever tricks and thus earn rewards. Even worms can learn; worms can be taught to do things. Strange as this sounds, it is quite true; although, naturally, worms can only learn the simplest of tasks. Here is an experiment which shows that an ordinary earthworm can learn. A worm is put, head-end first, into a glass tube. This tube is a branched one; it is shaped like the letter Y. The worm crawls forward into the tube and soon comes to the place where the tube branches into two. Here the worm can crawl either to the right or to the left. Sometimes it goes one way, sometimes the other. But in the experiment there is an arrangement by which if the worm takes the left-hand turn it gets a slight electric shock; if it crawls to the right it gets no shock. After our worm has been made to crawl into the tube a number of times it slowly learns to avoid the left-hand turn, where it gets a shock. In the end it nearly always turns to the right. The worm has learnt its lesson.

Birds know how to build their nests and rear their brood by instinct, without being taught, but there are other activities which they must learn. Some birds have even got to learn what to eat. After a chick hatches out of the egg, it pecks at every small thing within its reach. A chick has an instinct to peck, but it has no instinct to peck at the right things to eat. It pecks equally at small stones, grains of corn, nails,

the eyes of other chicks, and so on. But a chick learns very quickly by experience of mistakes made that grain is good to eat and stones are not. It very quickly finds that corn is good and pebbles are not, and it remembers this lesson. If chicks are given at the same time caterpillars that taste nice to them and another kind of caterpillar that tastes nasty, at first the chicks are unable to distinguish one kind of caterpillar from the other. They peck at both the nasty-tasting and the nice-tasting insects. But after only one or two trials of the nasty kind of caterpillar, the chicks never peck at it again. Chicks learn quickly what to eat.

We have considered firstly muscular learning, such as learning to walk or training for a sport; secondly learning by imitation, especially the young imitating their parents; and thirdly the most frequent kind of learning, which is by experience, that is by avoiding past mistakes. Those animals which learn quickest in this last-mentioned way are said to be the most intelligent. Dogs which learn tricks quickest are intelligent dogs. But there is yet another sort of learning, which we may fairly put in a higher category. This is by reasoning, by thinking out the various aspects of a situation and then acting.

Are there any animals which, when they meet with a new situation, think things out for themselves, make up their minds, and then act? Can any animals find the solution to a difficulty which they have never met before, and which they do not know how to solve by inborn instinct? In other words, can they reason? There are, in fact, animals that can do this; apes and monkeys can reason. This has been established by scientific experiments; here is a description of one such experiment.

A banana was hung by a string from the ceiling of a room. There were two small packing cases and a biscuit tin in the room. A monkey brought into the room wanted the banana, but could not reach it. He sat and looked for a short time at the banana and at

the boxes. Then suddenly he got up, put one box on the other, placed the tin on the top box, climbed on the tin, and got the banana. This was something quite new for the monkey: he had never before piled up boxes to get down a banana. It is not as if the monkey had learnt by experience to do this; he had never had to get over this difficulty before. Evidently the monkey actually thought out how to do it; the animal exercised reason. It has been proved by other experiments that monkeys and apes can reason in various simple ways. This is quite a different matter from learning how to do something by trying all kinds of ways at random until one of them succeeds, and then remembering this procedure.

Monkeys can think out for themselves how to perform simple purposeful actions, but can dogs do anything of the same sort? Can dogs also reason? Here is the sort of problem with which a dog might be confronted. There is a bone behind a wire fence and a dog sees the bone right in front of it through the fence. The dog has never been in this situation before. There is a gap in the wire fence, but the gap is not in front of the dog; it is some way along the fence. The dog can easily see this gap in the fence. Does a dog in such a situation ever think things out and decide that if it goes straight along to the gap it can then get through the fence and reach the bone? Does the dog make straight for the gap and go through it to the bone? Or, on the other hand, does the dog just dash to and fro, eventually finding the gap by chance and so getting through it to the bone? The dog would then remember how to get straight to the bone when next it met this situation. In other words, does a dog ever think things out as the monkey did, or does it always get over its difficulty by trial and error and then remember how to do it next time? Many biologists who have studied dogs think that on the first occasion a dog would find the gap in the fence only by chance, and later remember it; on the first occasion it would

not think things out and decide that it could get the bone by going straight to the gap. But this may not be the reader's opinion.

Intelligence tests, as used in schools, are a sort of exam to find out if pupils can reason, if they can put two and two together and come to a conclusion. The monkey who thought out how to get the banana reasoned and could rightly be described as intelligent in the same sense that a child is intelligent who gets a good mark in an intelligence test. But, as explained already, an animal is also said to be intelligent if it is quick at profiting by experience and has a good memory of the way to avoid past mistakes. This is why I said that the word Intelligence is ambiguous and is used differently by schoolmasters and pet-lovers. Without carefully controlled scientific experiments it is not possible to decide which of the two types of intelligence an animal has got.

At the beginning of the preceding chapter it was pointed out that the word Instinct, too, may be ambiguous. It will now be clear that when a person says "I did it instinctively," this does not necessarily mean that he was making use of an instinct. It does not mean that he did the action with an inborn instinctive knowledge of how to do it, but much more probably that he was just subconsciously profiting by his own past experience of similar situations.

In conclusion we may truly say that those animals which have fewest instincts possess most personality. For in the case of animals endowed with few inborn instincts, each individual in its lifetime accumulates a different store of experiences, on which it acts; each individual is different from its neighbours. The instinctive animal—the insect, and to a lesser degree the bird—is more stereotyped and has less personality. Mammals, and more particularly man, have fewest instincts, and therefore have the greatest degree of personality.